Planning of Water Resources of Rajasthan State

Report Number:

4.1

Report Name:

Hydrology and Weather

Background: Over 2013-2014, a consortium of firms led by Tahal Group produced a set of reports on the subject for the Government of Rajasthan. 9 reports were produced, as follows:

Report No.	Report Name
4.1	Hydrology and Weather
4.2	Basin-wise water availability
4.3	Catchment area study
4.4	Groundwater
4.5	Water pollution
4.6	Water supply demand
4.7	Identification of new projects
4.8	Identification of projects to be rehabilitated
4.9	Comprehensive water resources plan

With some exceptions, all the above reports have been uploaded on archive.org and may be found by searching for “Planning of Water Resources of Rajasthan State”

Final Report No. 4.1

Volume 1 of 3

Report

STUDY ON PLANNING OF WATER RESOURCES OF RAJASTHAN

INRM Consultants Pvt Ltd

Final Report No. 4.1

Agroclimatic Zone-Wise Hydrology and Weather

Volume 1
Report

February 2013

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Volume 2

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Volume 3

Maps

1 Maps of Various Climatological Parameters of Agroclimatic Zones (110 Nos.)
2 Landuse Maps of Agroclimatic Zones (10 Nos.)

Abbreviations and Acronyms

ACZ	Agro-Climatic Zone
AWS	Automatic Weather Station
CGWB	Central Ground Water Board
CSR	Commencement-of-Sowing Rains
CV	Coefficient of Variation
CWC	Central Water Commission
DAC	Data Acquisition Centres
DDP	Desert Development Program
d/s	Downstream
EPA	Environment Protection Authority
ET	Evapotranspiration
FDC	Flow Duration Curve
GCA	Gross Command Area
GIS	Geographical Information System
G&D	Gauge and Discharge
GDP	Gross Domestic Product
GOI	Government of India
GOR	Government of Rajasthan
GSI	Geological Survey of India
GSM	Global System for Mobile Communication
GW	Groundwater
ha	Hectare
HP	Himachal Pradesh State
hr	Hour
HS	Hydrometric Stations
ID	Irrigation Department (of Rajasthan)
IGNP	Indira Gandhi Nahar Project
IMD	India Meteorological Department
JJAS	June-July-August-September
kg	Kilo gram
km^2	Square kilometre
m	metre
m^2	Square metre
m^3	Cubic metre
Max.	Maximum
MCM	Million cubic meters

m^3/hr	Cubic metres per hour
Min.	Minimum
Mm^3	Million cubic metres
Mm^3/yr	Million cubic metres per year
mm	millimetre
MRS	Monthly Runoff Simulation
N	North
Na, NA (or n.a.)	Not applicable, or not available
NE	Northeast
NW	Northwest
NWDPRA	National Watershed Development Program For Rain-Fed Agriculture
PCA	Primary Census Abstract
PH	Power House
PHED	Public Health Engineering Department
PZ	Piezometer
RGWD	Rajasthan Ground Water Department
RH	Relative Humidity
RHS	Right-hand side
RS	Rainfall Stations
RSGWD	Rajasthan State Groundwater Department
RWRD	Rajasthan Water Resources Department
S	South / Storativity
SE	Southeast
SRRG	Self-recording Rain Gauge
SW	Surface Water; South-west
SWAT	Soil and Water Accounting Tool
SWRD	State Water Resources Department
T	Tonne; Transmissivity; Temperature
ToR	Terms of Reference
UA	Urban Agglomeration
u/s	Upstream
VSAT	Very Small Aperture Terminal
WAPCOS	Water and Power Consultancy Services (India) Ltd.
WLR	Water Level Recorders
WMO	World Meteorological Organization
WRIS	Water Resources Information System
WRPD	Water Resources Planning Department
yr	Year

1. Executive Summary

Agriculture in Rajasthan is mostly dependent on the monsoon, which is not only erratic and uncertain but also has a short time-span.

In terms of agro-climatic characteristics, the State ranges from arid to semi-arid.

The climatic conditions in Rajasthan affect the choice of cropping patterns in different areas, thus producing different crops. Rainfall, temperature, humidity, wind velocity and duration of sunshine, significantly affect the choice of crop and adoption of cropping patterns. Rainfall and its distribution over the year, and the regimes of diurnal and annual temperatures are by far the prominent factors affecting agriculture and the life style of people.

The State’s mean annual rainfall is 495.6 mm, and the number of rainy days is 27.

The state of Rajasthan encompasses ten agroclimatic zones (ACZ):

Ia – the Arid Western zone

Ib – the Irrigated North-western Plain

Ic – the Hyper-Arid Irrigated Western Plain Partially

IIa – the Transitional Plain of Inland Drainage

IIb - the Transitional Plain of Luni Basin

IIIa – the Semi-Arid Plain

IIIb – the Flood-Prone Eastern Plain

IVa – the Sub-Humid Southern Plain

IVb – the Humid Southern Plain

V – the Humid South-Eastern Plain

ACZ Ia is one of the most arid parts of the State, where the annual rainfall, which is quite often erratic, ranges between 100 and 400 mm. Mostly rain-fed crops like bajra, Kharif pulses, guar etc. are grown during the Kharif season. Crops like wheat, rape-seed and mustard are grown the Rabi season.

ACZ Ib is extremely arid, but is rich in agricultural produce thanks to the well-developed system of irrigation canals. The large network of Gang and Bhakra Canals, along with the Indira Gandhi Canal, has made the entire area green and productive. In the Rabi season, wheat, mustard, gram, vegetables and fruits are produced.

ACZ Ic is among the most arid parts of the State. The annual rainfall ranges between 100 and 350 mm and is quite erratic. However, in the area under command of Indira Gandhi canal crops raised in Kharif include cotton, maize groundnut etc., and wheat, mustard, barley, coriander, taramira and cumin are grown in Rabi season.

ACZ IIa is climatically slightly better than the adjoining Arid Western Plain. Temperatures in summer months are very high but the winters are very cold. Irrigation is restricted to areas with good groundwater potential. Bajra, sesamum and kharif pulses are the main crops of the rainy season. Wheat, barley, mustard and gram are grown as irrigated crops or on conserved soil moisture during Rabi.

ACZ IIb has semi-arid climate with an annual rainfall of 300 to 500 mm. Vegetation is sparse in the western part but in the east and on the slopes of the Aravalli range there are woodlands, open forests and grasslands. The area produces bajra, maize, guar, sesamum and pulses in the Kharif season. In the Rabi season, wheat, barley and mustard are the dominant crops, especially in irrigated areas.

In ACZ IIIa the annual rainfall varies from 500 to 600 mm with an increasing trend towards the east. Summer temperatures may reach around 47°C, and in winter the minimum may reach 5°C. Surface water sources are scarce and therefore harnessing of groundwater resources has been increasing at an accelerated pace. Productivity of all crops in this zone is better than that of the agro-climatic zones to the west of the Aravalli range. Bajra, sorghum and pulses are grown in the Kharif season, and wheat, barley, gram and mustard in the Rabi season.

ACZ IIIb has rich alluvial soils, the fertility of which is replenished every year by the flood water of the rivers. A network of canals drawing from the upper Yamuna Canal and the Panchana Dam irrigate this area. The region produces bajra, sorghum, maize, sugarcane, sesamum and a variety of pulses in the Kharif season. Wheat, barley, gram and mustard are the dominant crops during Rabi season

ACZ IVa has a moderately warm climate in summer and mild winters. The annual rainfall varies from 500 to 950 mm. The area produces maize as the chief food crop of the Kharif season but in irrigated areas, paddy rice is also grown. In the Rabi season, wheat, gram and oil seeds are the main crops. In areas of black soil, cotton and opium are also cultivated.

ACZ IVb has a humid climate with an average annual rainfall of more than 700 mm, with mild winters and summers. Cotton and sugarcane are the chief cash crops grown in the black soil region. Maize, sorghum and paddy rice are the chief food crops of the Kharif season. Groundnut, mustard, sesamum and rapeseed are also grown.

ACZ V has warm summers but mild winters. Summer temperatures sometimes touch 45°C. The development of canal irrigation systems with a series of dams and barrages on River Chambal has made this area rich in agricultural production. Paddy rice and sorghum are the chief food crops grown in the Kharif season. Wheat, barley, gram and mustard are grown in winter.

The Consultants have inspected several rain-gauging and river-gauging sites according to the ToR requirements, and found out that the majority of the instruments are either wrongly installed, inoperative, missing or improperly attended to. A detailed proposal for acquiring and installing new, modern equipment is has also been presented.

Rainfall data collected by the Consultants included numerous gaps and had to be filled-in by different methods. There are 542 listed rainfall stations, of which 327 were filtered out for filling of data gaps and utilizing in these studies.

The Consultants studied the applicability of the MRS (Monthly Runoff Simulation) model, which was applied during the preceding stage of the present study, versus that of the SWAT (Soil and Water Assessment Tool), and decided to use the SWAT, which offers more possibilities of including climatic and other factors in the analysis. The resulting estimates of surface water availability by river basin have been presented in Final Report No. 4.2 – Surface and Ground Water Availability by Basin and Sub-Basin.

Impact of change in observed Climatology on Water resources and crops of Rajasthan is summarized below:

Detailed analysis has been performed using major meteorological parameters (like Temperature, Humidity, Wind Speed, Evaporation) over the 20 years of the observation period of data availability. All the parameters but for the temperature have not shown any significant trend. However, the analysis performed on the observed temperature data for the Rajasthan State has revealed the following.

Mean Maximum and Minimum temperature for Rajasthan during the study period of 20 years (1990-2009) is 33.2°C and 19.1°C, respectively.

The Mean Maximum temperature shows an increasing trend with 90% confidence level over the period of observation of 20 years and the increase has been 0.8°C.

Similarly, the Mean Minimum temperature has also shown an increasing trend with 98% confidence level over the period of observation of 20 years and the increase has been 1.1°C.

The mean highest maximum temperature and mean lowest minimum temperature are 45.2°C and 3.3°C, respectively.

Trend analysis shows that there is a significant positive trend in the both mean maximum temperature and minimum temperature, thereby increasing the concern for crops and water conservation. Increased temperature may shorten the length of growing periods resulting reduced yield and increased crop water demand. Increase in evaporation may affect the open water bodies or storage structures. Increase in temperature with long period of dry spells may affect the soil moisture status.

The likely outcomes of increase in temperature and adaptation strategies that need to be taken by policy makers are given below:

- Increase in temperature would reduce the crop duration and result in reduced crop yield and would also lead to enhanced evaporation and plant water demand. This condition could modify the soil-water balance which in turn could negatively affect crop production, indirect implications may be on the livelihood and migration.
- Water conservation as underground water than surface water to reduce the evaporation losses

This increasing trend in temperature is definitely going to have some adverse impact on the local hydrology but on the other hand at some places there is increasing trend in rainfall. SO in general it can be said that the above two parameters may compensate each other.

2. Introduction

This is the first of nine Final Reports to be issued by the Consultants according to the Study’s Terms of Reference (ToR).

This report is an updated version of Draft Final Report No. 3.1, titled Report on Agroclimate, Hydrology and Weather. In addition to updated information, the present report incorporates the modifications concerning Draft Final Report No. 3.1, which were required in the light of observations and comments raised by the Review Committee of Rajasthan Water Resources Planning Department (RWRPD).

For the preparation of this report the Consultants have gathered information from various sources, including Central Water Commission, Rajasthan State Water Resources Department, Rajasthan Ground Water Department, the Central Ground Water Board, India Meteorology Department, State Revenue Department, Public Health Engineering Department, Industries Department and Agriculture Department.

The Table of Contents above includes a list of all the Appendices presented in Volume 2 of this report.

The present edition incorporates all the improvements required in the light of the comments of the review Committee at that stage, as well as the improvements and updating required in the light of an extensive study and analysis of more recently available climatic and hydrological data by the Consultants.

3. Objectives

The principal objectives of the study of agroclimatic zone-wise hydrology and weather can be stated as follows.

- Identify and define the various Agroclimatic Zones (ACZ)
- Collect and validate the data essential and relevant for the study
- Define the factors affecting changes in local climate and water resources
- Recommend improvements in hydrometric, meteorological and rain gauge stations with respect to their location, distribution, instrumentation and operation, in order to get more reliable and useful data in future.
- Incorporate validated agroclimatic zone-wise hydrology and weather data in the comprehensive database of the current Study.

4. Approach

The Consultants have followed in this report the relevant requirements in the terms of reference (ToR), which include the following (quoted):

> “River Gauging Sites, Rain Gauges and Meteorological Stations:
> - Carry out field surveys of sample sites
> - verify the stations’ locations and correct names
> - assess the deficiencies in working and adequacy of the network
> - review and give recommendations with regard to instrumentation, closing or upgrading or improvement of existing sites and opening of new sites
>
> Analyse the agroclimatic zone-wise hydrology, climate, cropping patterns and productivity
>
> Suggest strategies for improving cropping patterns and water use.”

The task of recommending improvements in hydrometric, meteorological and rain-gauge stations contains two sub-tasks, as follows.

1. Recommending improvements in hydrometric, meteorological and rain-gauge stations with respect to their instrumentation and operation.

   This objective was achieved by performing field visits to a sample of stations (more than 10% of rain-gauges and hydrometric stations, as per the ToR), and assessing the condition of instruments and their installation according to international standards. The experts performing field visits have also assessed the quality of the operation of the stations by interviewing their operators.

The visited meteorological and rain-gauge stations were selected so as to represent the various meteorological conditions.

An earlier detailed program for installing modern equipment in meteorological and hydrometric observatories was prepared by the Australian company MinData. Based on this the Rajasthan Water Resources Department (RWRD) prepared bid documents for acquiring and installing the necessary instruments.

2. Recommending improvements with respect to the location and distribution of stations.

   This objective was achieved by verifying the location (i.e. coordinates) of all stations by type, mapping them along with agroclimatic zones and river basins, and checking whether the network of meteorological stations effectively covers the agroclimatic zones and whether the hydrometric and rainfall gauges adequately cover the major river basins. Based on this, recommendations for improving the spread of rain-gauges over the State have been given.

   It should be noted that a) each station has different problems and it is incorrect to draw conclusions from one station to another, and b) measurement errors in a station should be identified and quantified according to the findings of a field visit as well as desk studies.

3. IWRM

   The National Water Mission (NWM) has recognised IWRM at the basin level as the foundation upon which the implementation of adaptation to climatic change can be realised. It is very likely that a particular agroclimatic zone may contain one or more river basins or conversely a river basin might have areas belonging to different agroclimatic zones. Therefore for assessing water supply and demand water balance approach is desirable which needs to be taken up at the hydrological boundaries of catchment/basin. However, agroclimatic zone can play an important role to study the inherent characteristics of the land mass from the view point of agricultural management practices, crop suitability, etc. Detailed note on Integrated Water Resource Management (IWRM) and Adaptation to Climate Change is presented in Appendix 1 (Volume 2 of this report).

5. Methodology

5.1 Data Collection

5.1.1 General

The Consultants have carried out a reconnaissance of all the river basins of Rajasthan to assess the hydrologic characteristics of watersheds, vegetative cover, the stream network, regional geology, soil characteristics, hydro-geologic characteristics, climate and topographical features.

In addition, the Consultants have received from the State Water Resources Department (WRD) digitized maps and records required for the performance of the present Study.

A surface water key map prepared by the Consultants is attached in the back-cover pocket, showing the various rivers, river basins and riverflow gauging sites.

5.1.2 Surface Water Data

a. General

According to available records, there were 52 listed Gauge and Discharge (G&D) sites which can be used for assessment of surface water yields - 25 streamflow gauging sites maintained by Water Resources Department (WRD) and 27 by Central Water Commission (CWC) sites, located inside and outside Rajasthan, as described in continuation by river basins.

b. Shekhawati

Only one site at Ringus, maintained by CWC, is located in this Basin, but it was closed down in the year 1984. Data were collected for 4 years (6/81 to 9/84).

c. Ruparail

No streamflow gauging sites exists in this Basin.

d. Banganga

One site is maintained by WRD located in this Basin which is at Hingota.

e. Gambhir

Three sites maintained by WRD are located in this Basin. Data availability for these sites is from 1994 to 1998.

f. Parbati

No streamflow gauging sites exist in this Basin.

g. Sabi

Only one site maintained by WRD is located in this Basin. Data were collected for 29 years (1964-2000).

h. Banas

14 sites (8 WRD and 6 CWC) are located in this Basin. Out of 6 CWC sites, 2 sites, at Pipli (Banas) and Chittaurgarh (Berach), have been closed.

i. Chambal

15 sites (6 WRD and 9 CWC sites) are located in Chambal Basin, which could be used for the assessment of surface water yields.

j. Mahi

9 sites (5 CWC and 4 WRD) are located in Mahi Basin which could be used for the assessment of the yield of Mahi Basin. Out of 5 CWC sites, two are located in MP and one in Gujarat. Both WRD and CWC are maintaining sites at the same location at three places (Jakham at Nagalia Pickup Weir, Jakham at Dhariawad and Karmai at Karmai Pickup Weir).

k. Sabarmati

Two sites maintained by CWC (one in Gujarat) are located in this Basin. None of these data could be supplied by CWC, because discharges are not being observed regularly and properly.

l. Luni

5 CWC sites exist in Luni Basin, of which data can be used. Data for 5 sites (including 4 closed down), were collected from CWC.

m. West Banas

Only one CWC site at Abu Road is located in this Basin. Data were available from 1989 to 1991

n. Sukli

No streamflow gauging site is located in this basin.

o. Other Nallahs of Jalore

No streamflow gauging site is located in this basin.

p. Outside Basin

No streamflow gauging site is located in this undefined basin.

The following table lists all existing 52 Gauge and Discharge (G&D) sites, their locations and the respective authority in charge.

Table 5.1 River Gauge and Discharge (G&D) Sites

S. No.	G&D Site	River/ Stream	Basin	Maintained By
1	Chittorgarh	Berach	Banas	WRD
2	Chittorgarh	Gambhiri	Banas	WRD
3	Kanota	Dhund	Banas	WRD
4	Matrikundia Pick up-weir	Banas	Banas	WRD
5	Wagon	Banas	Banas	WRD
6	Gomti	Chhaper Kheri	Banas	WRD
7	Kothari	Banas	Banas	WRD
8	Negaria	Banas	Banas	WRD
9	Hingota	Banganga	Banganga	WRD
10	Shri Mahavirji	Gambhir	Gambhir	WRD
11	Samogarh Railway Bridge	Gambhir	Gambhir	WRD

S. No.	G&D Site	River/ Stream	Basin	Maintained By
12	Bayana Railway Station	Gambhir	Gambhir	WRD
13	Rana Pratap Sagar Dam	Chambal	Chambal	WRD
14	Jawahar Sagar Dam	Chambal	Chambal	WRD
15	Kota Barrage	Chambal	Chambal	WRD
16	Manohar Thana	Parwan	Chambal	WRD
17	Kalisindh Pick-up weir	Kalisindh	Chambal	WRD
18	Parwan Pick-up weir	Chambal	Chambal	WRD
19	Govindgarh	Saraswati	Banas	WRD
20	Mahi Dam	Mahi	Mahi	WRD
21	Dhariawad	Jakham	Mahi	WRD
22	Nagalia Pick-up-weir	Mahi	Mahi	WRD
23	Karmai Pick-up-weir	Mahi	Mahi	WRD
24	Aspur	Som	Mahi	WRD
25	Sodawas	Sabi	Sabi	WRD
26	Ringus (site closed)	Mendha	Shekhawati	CWC
27	Nimoda*	Morel	Banas	CWC
28	Pipli*	Banas	Banas	CWC
29	Tonk*	Banas	Banas	CWC
30	Pali Ghat	Chambal	Chambal	CWC
31	Mandawara	Chambal	Chambal	CWC
32	Aklera	Parwan	Chambal	CWC
33	Sangod*	Parwan	Chambal	CWC
34	Barod*	Kali Sindh	Chambal	CWC
35	Khatoli*	Parwan	Chambal	CWC
36	Salwad*	Kali Sindh	Chambal	CWC
37	Mandrail	Chambal	Chambal	CWC
38	Chittorgarh	Gambhiri	Banas	CWC
39	Bigod	Banas	Banas	CWC
40	Baranwada	Banas	Banas	CWC
41	Dholpur	Chambal	Chambal	CWC
42	Rangeli*	Som	Mahi	CWC
43	Anas at PH2*	Anas	Mahi	CWC
44	Chandangarh/ Mataji*	Mahi	Mahi	CWC
45	Paderdibadi*	Mahi	Mahi	CWC
46	Kadana*	Mahi	Mahi	CWC
47	Gandhav/Chitalvana*	Luni	Luni	CWC
48	Akdara* (site closed)	Mithri	Luni	CWC
49	Birami* (site closed)	Ugti	Luni	CWC
50	Sojat Road* (site closed)	Sukri	Luni	CWC
51	Alniawas* (site closed)	Luni	Luni	CWC
52	Abu Road*	West Banas	West Banas	CWC

* Sites for which data after 1997 are not available, except Khatoli and Salwad whose data of 1996 - 2004 are available.

5.2 Rainfall/Runoff Simulation Methods

The Consultants have thoroughly analysed the applicability of the MRS (Monthly Rainfall Simulation) model, which is referred to in the Terms of Reference, in comparison with the SWAT (Soil and Water Assessment Tool) described in Appendix 2 (Volume 2 of this report), and have adopted the latter.

Even though the MRS is less complicated as it uses monthly rather than daily rainfall and other climatic data, the SWAT offers more possibilities in applying data about the natural characteristics of a river basin, and has been preferred by the Consultants.

5.3 Surface Water Data Validation

5.3.1 Introduction

All data collected were analysed for format, data completeness, missing records, duplications and inconsistencies, prior to their use as an input to hydrological modeling.

Some record from standard rain-gauges may be missing or faulty due to poor observation technique, a wrong or broken measuring glass or a leaking jar. In these circumstances, it is necessary to correct the erroneous data or complete them prior to using them for any analysis. The standard rain-gauge data in such cases are made equal to those obtained from the autographic records.

The standard rain-gauges are normally observed once or twice a day, at 08:30 hrs or 08:30 and 17:30 hrs.

5.3.2 Problems and Bottlenecks in Carrying Out the Studies

The rainfall data have several quality problems. For instance, rainfall stations’ data are not uniform and continuous with respect to time period of observations; there are several stations where an entire year’s data are missing or are filled with zeros, and moreover:

- data are not stored in a proper uniform format,
- duplicity in location of rain gauge stations,
- duplicity in station names,
- stations at the same location have different names,
- incorrect station locations,
- stations with the same name have multiple locations,
- data missing in the rainfall series (from days to years),
- entire years have "0" data entries (not possible unless it is a declared a drought year),
- data continuity and consistency are not maintained.

The converted rainfall data underwent thorough and extensive validation, in terms of locations, station names, duplicities etc., to finalize the rainfall datasets of stations that are in working condition. The rainfall data for all such stations have undergone consistency checks (Double Mass Curve, as explained in Paragraph 5.3.5 below) and missing rainfall data, which may range from days to an entire year, were filled up (see Paragraph 5.3.3).

It is highly recommended that in future rainfall be measured continuously and consistently and should be stored in proper format with a uniform structure. Weather data like wind velocity, relative humidity and sunshine hours, which play an important role in evaluating evapotranspiration and other agro-meteorological data, are not measured. Automatic weather stations must be set up for measuring these data. It is recommended to measure these data at various locations within Rajasthan, as these parameters have high spatial and temporal variation.

In the absence of such data, the SWAT model makes use of long-term statistics to generate these values on a continuous basis.

5.3.3 Filling of Data Gaps in Rainfall Series

Precipitation data are the most important input in hydrological models. In many river basins, collected records have a large number of missing data (days, months and years). This could be due to different circumstances, for instance: absence of observers, problems with the measuring device, loss of records, or maybe the lack of funds to continue the measurements.

Before applying any hydrological model, data analysis has been executed first, to have complete rainfall records. Missing data were completed by using the Distance Power Method (see below).

There are 542 listed rainfall stations, of which 327 were filtered out for filling of data gaps.

The following methodology has been adopted by the Consultants to fill rainfall data gaps.

a. Station-wise daily rainfall data were extracted and stored in a uniform format with date and precipitation values (mm) in separate columns.
b. The number of missing records (days, months and years) was summarized.
c. Stations having more than 30 years of data, calculated back from year 2010, were filtered out.
d. A matrix of distances between each target station and the rest of stations was generated.
e. For each target station, base stations within 30 km radius were selected.
f. After applying these filters, 327 out of the 542 stations were selected for filling of rainfall data gaps. Details of the selected stations are given in Appendix 3 (Volume 2 of this report).
g. An index file with all target stations and their corresponding base stations was created, along with individual rainfall series files.
h. These two files were used as an input to the application, to fill the output of target stations. The program fills the missing data of target stations in only those dates where data of base stations are also available.
i. The program checks the start and end date of target stations and looks for missing values within the range. If it encounters any missing record it checks for the neighbouring base stations' data for the same date and fills the data according to the equation shown below.

j. The program first fills-in data of any missing date, and then looks for years whose Monsoon months' rainfall is zero. If it encounters such a year then those Monsoon months are filled.

5.3.4 The Distance Power Method

The Distance Power method has been applied for filling up gaps in the rainfall data.

This method weighs neighbouring stations on the basis of their distance from the station under consideration, assuming that closer stations are better correlated than those further apart, and that beyond a certain distance they are insufficiently correlated to be of use. Spatial interpolation is made by weighing the adjoining station rainfall as inversely proportional to some power of the distances from the station under consideration. Normally, an exponent of 2 is used with the distances to obtain the weighted average.

The adjoining stations are selected on the basis of the following:

- they must lie within a 30-km radius to have significant spatial correlation with one another
- a maximum of 8 adjoining stations is sufficient for estimating the spatial average
- a minimum period of 30 years of records should be present in the selected adjoining stations
- an equal number of stations from each of the four quadrants is preferred for minimizing any directional bias. However, due to prevailing wind conditions or orographic effects, spatial heterogeneity may be present. In such cases normalized values rather than actual values should be used in the interpolation

After applying all the filters listed above, 327 of the 542 rain-gauge stations were shortlisted for rainfall data gaps filling.

The spatially interpolated estimate of the rainfall at the station under consideration is obtained as:

$$P_{est,j} = \frac{\sum_{i=1}^{M_{base}} P_{i,j}/D_i^b}{\sum_{i=1}^{M_{base}} 1/D_i^b}$$

Where:

$P_{est,j}$ = estimated rainfall at the test station at time j

$P_{i,j}$ = observed rainfall at the neighbor station i at time j

D_i = distance between the test and the neighboring station i

M_{base} = number of neighboring stations taken into account.

b = power of distance D used for weighting rainfall values at individual station (in this case 2)

Comparison of various methods by which missing rainfall can be estimated is provided in Appendix 4 (Volume 2 of this report). It shows why the Distance Power method is better than other methods for estimating missing rainfall records.

A stand-alone application has been developed to fill rainfall gaps.

5.3.5 Consistency Checks

Consistency checks are performed for investigating the behaviour of rainfall data at a number of locations. It is used to determine whether there is a need for corrections to the data to account for changes in data collection procedures or other local conditions. Such changes may result from a variety of causes, including changes in instrumentation, changes in observation procedures, or changes in gauge location or surrounding conditions.

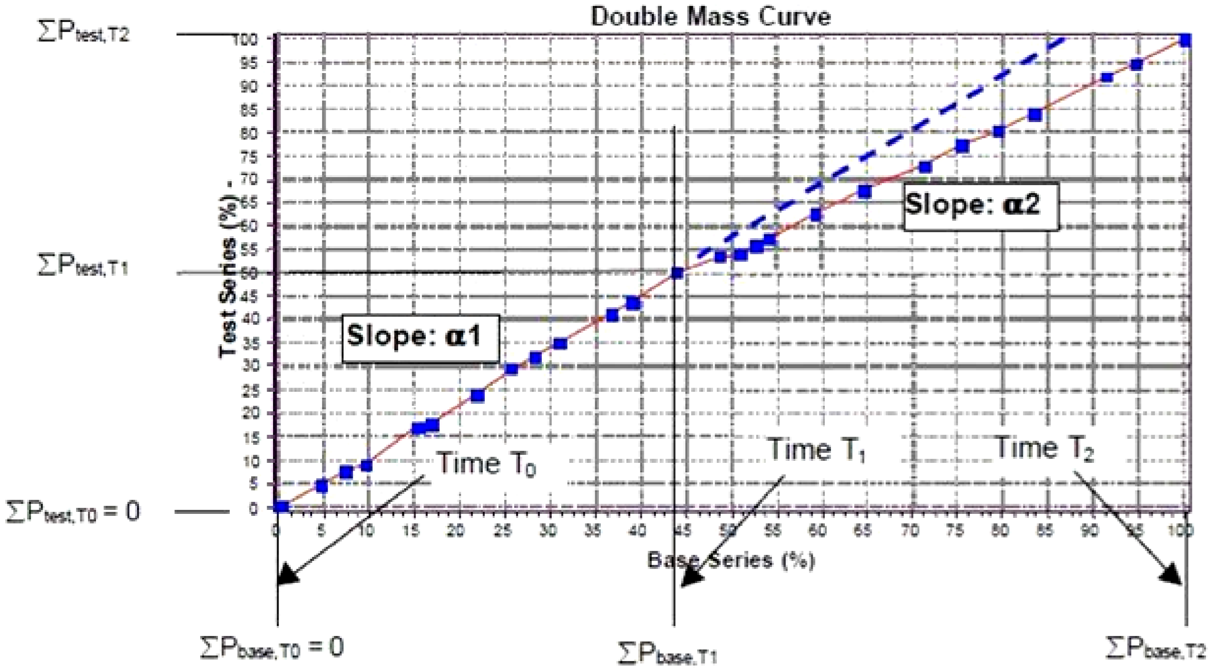
The double-mass analysis technique is used in data validation to detect significant long-term systematic shift in rainfall data. The same technique is used to adjust the suspected data. Inconsistency in data is demonstrated by a distinct change in the slope of the double-mass curve and may be due to a change in the location of the instrument or in its exposure or measurement technique. It does not imply that either period is incorrect - only that it is inconsistent.

The data can be made consistent by adjusting them so that there is no break in the double-mass curve. The existence of a discontinuity in the double-mass plot does not in itself indicate which part of the curve should be adjusted (before or after the break). In this process the adjustment is made to the later part.

The following methodology has been adopted by the Consultants to check consistencies, with a subsequent correction in the rainfall data for a given target station.

a. A group of n (usually 5 to 10) base stations in the neighborhood of the problem station X is selected.
b. Annual rainfall data of station X, and also the average rainfall of the group of base stations covering a long period, are arranged in chronological order.
c. Considering the double mass plot shown in Figure 5.1 below, the break point occurs at time T1 and the start and end times of the period under consideration are T0 and T2, respectively.

Figure 5.1 Double-Mass Curve Plot



The slopes of the curve before and after the break point can be expressed as:

$$\alpha_1 = \frac{\sum_{i=0}^{T_1} P_{test,i}}{\sum_{i=0}^{T_1} P_{base,i}}$$

and

$$\alpha_2 = \frac{\sum_{i=T_0}^{T_2} P_{test,i} - \sum_{i=T_0}^{T_1} P_{test,i}}{\sum_{i=T_0}^{T_2} P_{base,i} - \sum_{i=T_0}^{T_1} P_{base,i}}$$

The correction factor is expressed as:

$P_c = P_t \times \alpha_2 / \alpha_1$

Where:

P_c = Corrected observed rainfall of target station
P_t = Original observed rainfall of target station

After making such correction the double-mass curve is again plotted to see that there is no significant change in the slope of the curve.

A sample application of the double-mass-curve analysis is included in Table 7.7.

5.4 Evaporation/Evapotranspiration Estimates

In the present study, evapotranspiration (ET) is not measured directly but rather simulated using the SWAT model, which simulates actual evapotranspiration on a continuous basis. Once the model is validated, this output is the best way to get the actual ET assessment for an area. These outputs are very useful since they can also represent changes in land-use under a recommended strategy.

6. Characteristics of the Agroclimatic Zones of Rajasthan

6.1 Introduction

Agroclimatic zoning is mainly based on the type of soil, climate (rainfall etc.), main crops grown and irrigation facilities existing in different parts of the State. To delineate the Agroclimatic Zones (ACZ), the scientists of Indian Council of Agriculture Research and scientists working at various Agriculture Research Stations in the State Department of Agriculture, Rajasthan, are responsible. During the period 1981 to 1993 the National Agriculture Research Project (NARP) categorized Rajasthan as nine Agroclimatic Zones on the basis of soil types, climatic conditions and crop features, for the purpose of micro-level planning.

Later on, during 2008, based upon recommendations of the NARP, ACZ Ic, called Hyper-Arid and Irrigated Western Plain Partially, was delineated as the tenth ACZ, covering all the Tehsils of Bikaner and Jaisalmer Districts and -Sujangarh, Ratangarh, Sardar Shahar Tehsils of Churu Districts. This was done in due consideration of the introduction of surface irrigation.

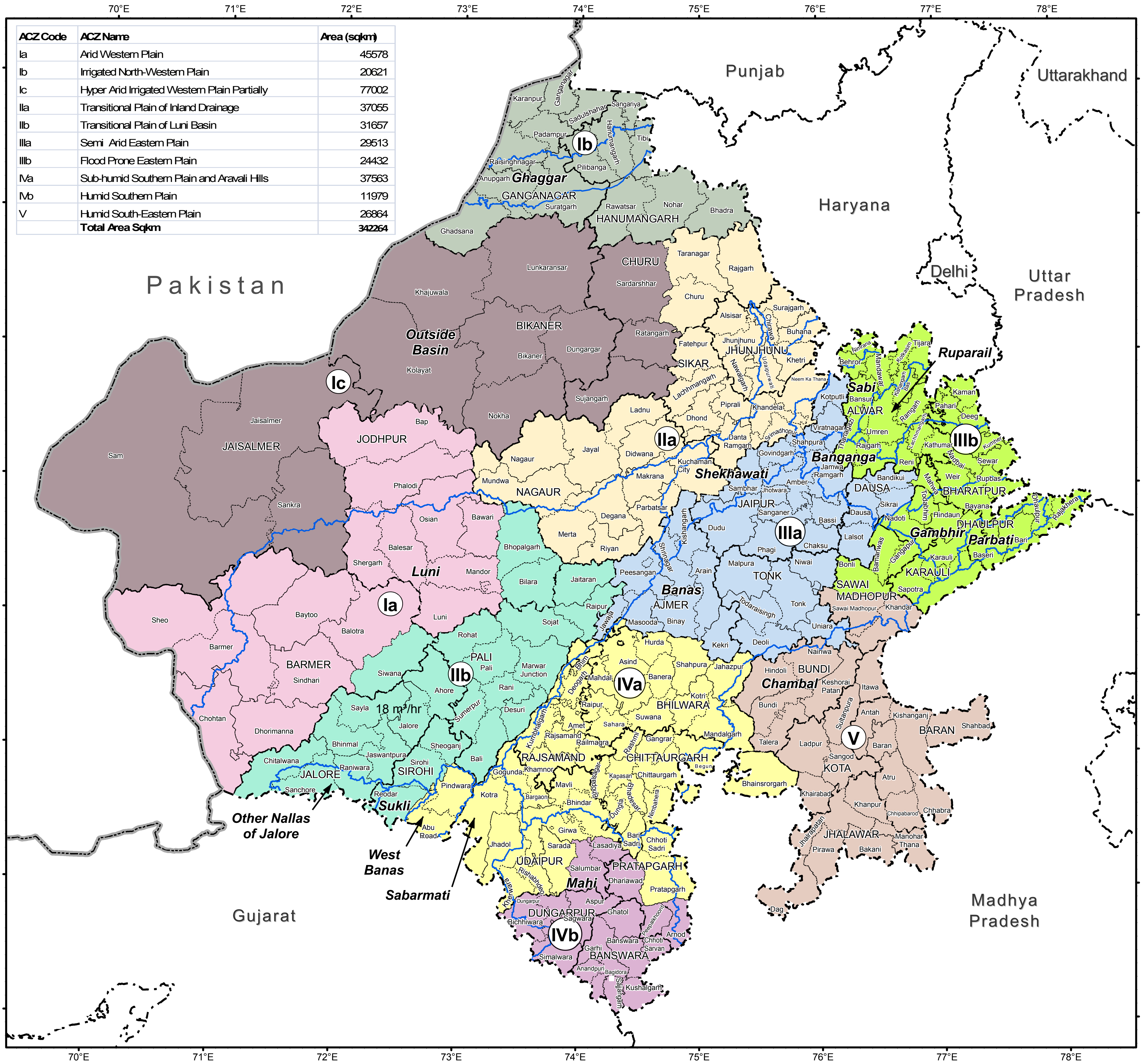
In accordance with these ACZs, the Department of Agriculture, Rajasthan, has established Adaptive Trial Centres (ATC), one in each ACZ.

The Agroclimatic Zones of Rajasthan are shown in Figure 6.1 along with River Basins of Rajasthan. More detailed map of Rajasthan’s Agroclimatic Zones is presented in the back cover pocket of this report.

Details describing the ACZs are presented in Table 6.1

Figure 6.1

ACZ Code	ACZ Name	Area (sqkm)
Ia	Arid Western Plain	45578
Ib	Irrigated North-Western Plain	20621
Ic	Hyper Arid Irrigated Western Plain Partially	77002
IIa	Transitional Plain of Inland Drainage	37055
IIb	Transitional Plain of Luni Basin	31657
IIIa	Semi Arid Eastern Plain	29513
IIIb	Flood Prone Eastern Plain	24432
IVa	Sub-humid Southern Plain and Aravali Hills	37563
IVb	Humid Southern Plain	11979
V	Humid South-Eastern Plain	26864
	Total Area Sqkm	**342264**



Agro Climatic Zones and River Basins
RAJASTHAN

Legend

Boundaries

┈┈┈	Block
╌╌╌	District
🟩	Agro Climatic Zone
▭	River Basin
─·─	State
─··─	International

Labels

Block

DISTRICT

State

Country

River Basin

ACZ

N
W E
S

0 50 100 150 200
Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:3,250,000

DATE: August, 2012

Table 6.1 Salient Features of the Agroclimatic Zones of Rajasthan

No.	Agroclimatic Zone	Districts (Blocks)	Area, Million ha.		Rainfall Range, mm	Temperature, °C		Major Crops (2 - 4 No.)		Soils
			Total	Net Sown		Max.	Min.	Kharif	Rabi	
Ⅰa	Arid Western	Part of Barmer (Barmer, Balotra, Baytoo, Chohtan, Dhorimanna, Sindhari, Sheo) and Jodhpur (Balesar, Bap, Part of Bhopalgarh, Luni, Mandore, Osian, Phalodi, Shergarh)	4.56	2.34	216-496	40.0	8.0	Pearlmillet, Mothbean, Sesamum	Wheat, Mustard, Cumin	Desert soils and sand dunes aeolian soil, coarse sand in texture some places calcareous
Ⅰb	Irrigated North Western Plain	Ganganagar and Hanumangarh	2.06	1.60	183-344	42.0	4.7	Cotton, Clusterbean	Wheat, Mustard, Gram	Alluvial deposits calcareous, high soluble salts and exchangeable sodium
Ⅰc	Hyper Arid Irrigated Western Plain Partially	Bikaner, Jaisalmer and Part of Churu (Ratangarh, Sardarshahar, Sujangarh)	7.70	2.44	192-420	48.0	3.0	Pearlmillet, Mothbean, Clusterbean	Wheat, Mustard, Gram	Desert soils and sand dunes aeolian soil, Loamy coarse in texture and calcareous
Ⅱa	Transitional Plain of inland drainage	Nagaur, Sikar, Jhunjhunu and Part of Churu (Churu, Rajgarh, Taranagar)	3.71	2.68	266-627	39.7	5.3	Pearlmillet, Clusterbean, Pulses	Wheat, Mustard, Gram	Sandy loam, shallow depth red soils in depressions
Ⅱb	Transitional Plain of Luni Basin	Jalore, Pali, Part of Sirohi (Reodhar, Sheoganj, Sirohi), Barmer (Siwana) and Jodhpur (Bilara, Part of Bhopalgarh)	3.17	1.93	139-1273	38.0	4.9	Pearlmillet, Clusterbean, Sesamum	Wheat, Mustard	Red desert soils in Jodhpur, Jalore and Pali sierozems in Pali and Sirohi
Ⅲa	Semi arid Eastern Plain	Ajmer, Jaipur, Tonk, Part of Dausa (Bandikui, Dausa, Lalsot, Sikrai)	2.95	1.77	313-694	40.6	8.3	Pearlmillet, Clusterbean, Sorghum	Wheat, Mustard, Gram	Sierozems, eastern part alluvial, west north west lithosols, foot hills, brown soils
Ⅲb	Flood Prone Eastern Plain	Alwar, Bharatpur, Dhaulpur, Karauli, Part of Dausa (Mahuwa) and Sawai Madhopur (Bamanwas,	2.44	1.41	140-736	40.0	8.2	Pearlmillet, Clusterbean, Groundnut	Wheat, Barley, Mustard,	Alluvial prone to water logging, nature of recently alluvial

No.	Agroclimatic Zone	Districts (Blocks)	Area, Million ha.		Rainfall Range, mm	Temperature, °C		Major Crops (2 - 4 No.)		Soils
			Total	Net Sown		Max.	Min.	Kharif	Rabi	
		Bonli, Gangapur)							Gram	calcareous has been observed
IVa	Sub humid Southern Plain	Bhilwara, Chittaurgarh, Rajsamand, Part of Sirohi (Abu Road, Pindwara), Udaipur (Bargain, Bhinder, Girwa, Gogunda, Kherwara, Kotra, Jhadol, Mavli, Sarada) and Pratapgarh (Choti Sadri, Pratapgarh)	3.76	0.92	311-1470	38.6	8.1	Maize, Pulses, Sorghum	Wheat, Mustard, Gram	Soil are lithosol at foot hills and alluvial in plains
IVb	Humid Southern Plain	Dungarpur, Banswara, Part of Udaipur (Salumber) and Pratapgarh (Dhariyawad, Peepalkhunt, Arnod)	1.20	0.57	511-1043	39.0	7.2	Maize, Paddy, Sorghum, Black Gram	Wheat, Mustard , Gram	Predominantly reddish medium texture, well drained calcareous, shallow on hills, deep soil in valleys
V	Humid South-Eastern Plain	Baran, Bundi, Jhalawar, Kota, Part of Sawai Madhopur (Khandar, Sawai Madhopur)	2.69	1.27	452-985	42.6	10.6	Sorghum, Soyabean	Wheat, Mustard	black, of alluvial origin, clay loam,
Total			34.23	16.93						

Source: Rajasthan Agriculture Statistics at a glance 2009-10 and present TAHAL study

6.2 Arid Western Plain (Ia)

This region comprises parts of Barmer District (Barmer, Balotra, Baytoo, Chohtan, Dhorimanna, Sindhari and Sheo Blocks) and Jodhpur District (Balesar, Bap, part of Bhopalgarh, Luni, Mandore, Osian, Phalodi, and Shergarh Blocks). This is one of the most arid parts of the State where the annual rainfall, which is quite often erratic, ranges between 216 to 496 mm.

Summer temperatures are always high and the diurnal range even exceeds 20°C. During the day, the summer temperatures may be as high as 49°C but in the night, the temperatures may fall to less than 20°C. In winters, the day temperatures are comparatively higher but the night temperatures may drop drastically. Winters are of short duration, not exceeding two months - December and January.

This is an area of not-so-developed drainage system. Owing to poor rainfall, surface water resources do not exist while ground water resources are often deep and brackish. Natural vegetation is therefore only seasonal. With the first showers in late July, a few grass species grow and shrubs and dwarf trees become green. But, soon after the retreat of the Monsoon in mid September, the vegetation dries up, leaving only a few perennial shrubs and a thin pad of pale grass on the landscape.

Mostly rain-fed crops like bajra, Kharif pulses, guar etc. are grown during the Kharif season. Rabi crops like wheat, rape-seed and mustard are mostly grown with irrigation.

6.3 Irrigated North-Western Plains (Ib)

The entire area of Ganganagar and Hanumangarh Districts is an alluvial and aeolian plain, formed by the river Ghaggar. The Ghaggar channel, even though quite wide at some places, often inundates nearby villages during heavy rainfall in its catchment areas.

The arid part of this region is the northern extension of the Indian Thar Desert, covered with wind-blown sand. Extreme aridity, marked with high summer and low winter temperatures, is its usual climatic characteristic. The annual rainfall ranges between 183 and 344 mm. High-velocity winds blow in summer. The area is rich in agricultural produce on account of a well-developed system of canal irrigation; the large network of Gang Canal and Bhakra Canal, along with the Indira Gandhi Canal, has made the entire area green and productive.

Due to abundance of canal water irrigation, this region has today become the granary of Rajasthan. Amongst the Kharif crops, cotton, sugarcane, groundnuts, guar and pulses are of importance. In the Rabi season, wheat, mustard, gram, vegetables and fruits are produced. Total production and productivity levels of all the crops, are relatively much higher in this zone than other parts of the State.

6.4 Hyper-Arid and Irrigated Western Plain Partially (Ic)

The areas under command of Indira Gandhi canal in the Districts of Jaisalmer, Bikaner and part of Churu (Ratangarh, Sardarshahar, and Sujangarh Blocks) are under agroclimatic zone Ic. This is among the most arid parts of the State. The annual rainfall ranges between 192 and 420 mm and is quite erratic. The rainfall may not only vary from year to year but also fluctuates in the same year. Median dates of commencement-of-sowing rains (CSR) are 15th July in Jaisalmer, 8th July in Bikaner and 30th June in

Churu. Summer temperatures may range between 40°C and 42°C during June; temperatures may fall to less than 6°C to 8°C during January. Mean annual potential evapo-transpiration may range between 160 to 200 mm. The duration of winter is generally short, mostly occurring during the months of December and January. Because of low rainfall, local surface water resources do not exist. Ground water is generally deep and brackish. Natural vegetation is generally seasonal. A few grass species come up with the onset of Monsoon. This vegetation dries up by mid September. Rain-fed crops like bajra, guar, Kharif, pulses etc. are generally raised. However, with the availability of canal irrigation water, crops raised are cotton, maize groundnut etc. in Kharif, and wheat, mustard, barley, coriander, taramira and cumin in Rabi season.

6.5 Transitional Plain of Inland Drainage (IIa)

This zone comprises Nagaur, Sikar, Jhunjhunu Districts and part of Churu District (Churu, Rajgarh, and Taranagar blocks). The area is covered with sand dunes and inter-dunal sandy plains. Drainage is not well developed, and streams that flow in the rainy season disappear in sandy fields after covering some distance. Climatically, this zone is slightly better as compared to the adjoining zone of the Arid Western Plain. Rainfall is slightly higher, temperatures in summer months go very high but the winters are very cold. Irrigation is restricted to areas with good groundwater potential.

Bajra, sesamum and kharif pulses are the main crops of the rainy season. Wheat, barley, mustard and gram are grown as irrigated crops or on conserved soil moisture during Rabi.

6.6 Transitional Plain of Luni Basin (IIb)

This area lies between the Aravalli range and the western arid region. The region encompasses the districts Jalore, Pali, Part of Sirohi District (Reodhar, Sheoganj and Sirohi Block), Barmer District (Siwana Block) and Jodhpur District (Bilara and part of Bhopalgarh Blocks). The region has semi-arid climate with an annual rainfall of 134 to 1273 mm. It is drained by river Luni, which is seasonal and flows only during the rainy season. A number of paleo-channels also exist in this area. The western part of the region is dotted with sand dunes, interspersed in alluvial soil. Luni and its several tributaries, like Sukri, Mithri and Jawai have made this area productive. The climatic conditions are almost the same as in the western arid region, except that the rainfall is slightly higher. The groundwater level is high in the river basins, and has been usefully tapped for irrigation. Vegetation is xerophytic and sparse in the western part, but in the east and on the slopes of the Aravalli ranges there is mesophytic vegetation in the form of woodlands, open forests and grasslands.

The area produces bajra, maize, guar, sesamum and pulses in the Kharif season. In the Rabi season, wheat, barley and mustard are the dominant crops, especially in irrigated areas.

6.7 Semi-arid Eastern Plain (IIIa)

This region comprises Ajmer, Jaipur and Tonk Districts, and part of Dausa District (Bandikui, Dausa, Lalsot, and Sikrai Blocks). River Banas, with its several tributaries, forms a rich fertile plain.

On the western side, this region is flanked by the low Aravalli hills which extend from south-west to the north-east.

The annual rainfall of the region varies from 313 to 694 mm with an increasing trend towards the east. Summer and winter temperatures are not as extreme as in the arid west. Summer temperatures may reach around 47°C, and in winter the minimum may reach 5°C. Depth to water table varies from 15 to 25 m, but the annual fluctuations are high, especially in the years when the south-west Monsoon fails and the yearly replenishment is low. Surface water sources are scarce and therefore harnessing of groundwater has been increasing at an accelerated pace. Natural vegetation is of the mixed xerophytic and mesophytic type, but owing to heavy felling of trees, the surface mantle has been robbed of its natural wealth. In the total gross cultivated area of this zone, bajra, sorghum and pulses are grown in the Kharif season, and wheat, barley, gram and mustard in the Rabi season. Productivity of all crops in this zone is better than that of the agroclimatic zones to the west of the Aravalli range.

6.8 Flood-Prone Eastern Plains (IIIb)

This region comprises Alwar, Bharatpur, Dhaulpur and Karauli Districts, and part of Dausa District (Mahuwa block) and Sawai Madhopur District (Bamanwas, Bonli, and Gangapur blocks). Except for few low hills which exist in Alwar and Sawai Madhopur Districts, the entire region is a flood plain of Banganga and Gambhir rivers. The region has rich alluvial soils, the fertility of which is replenished every year by flood water of the rivers. In periods of heavy rainfall, the rivers outflow their banks and inundate the surrounding villages.

Climatically, the area is similar to the plains of Banas, but the rainfall is relatively higher in the east, the annual amount being between 140 and 736 mm. Natural vegetation exists on mountain slopes, wetland areas and protected zones, but the excessive plundering of forest wealth has depleted the natural cover. The region produces a variety of crops because both surface water and ground water irrigation sources exist. A network of canals drawing from the upper Yamuna Canal and the Panchana Dam irrigate this area. Depth to groundwater table varies from 5 to 15 m, and therefore well-water irrigation is also practiced. The region produces bajra, sorghum, maize, sugarcane, sesamum and a variety of pulses in the Kharif season. Wheat, barley, gram and mustard are the dominant crops during Rabi season.

6.9 Sub-humid Southern Plains and the Aravalli Hills (IVa)

This region comprises the Districts of Bhilwara, Chittaurgarh and Rajsamand, and part of Sirohi District (Abu Road and Pindwara Blocks), Udaipur District (Bargain, Bhinder, Girwa, Gogunda, Kherwara, Kotra, Jhadol, Mavli and Sarada Blocks) and Pratapgarh District (Choti Sadri and Pratapgarh blocks). This is a region of low Aravalli hills with the inter-mountain plateau, deeply dissected by streams and rivers. The region has a moderately warm climate in summers and with mild winters. The annual rainfall varies from 311 to 1,470 mm. The highest precipitation in the state is recorded in Abu hills (Sirohi District). There are a number of surface water streams, like Gambhir, Sabarmati, Banas and its tributaries, but they are all ephemeral. The surface rocks are granitic and highly metamorphosed, and so the depressions on the surface are filled with rain water in the form of natural reservoirs.

The area is rich in natural vegetation, which grows on the slopes of the Aravalli and in the wetland areas, but excessive felling of trees has degraded these open forests. Tank water irrigation is most common. The area produces maize as the chief food crop of the

Kharif season but in irrigated areas, rice is also grown. In the Rabi season, wheat, gram and oil seeds are the main crops. In areas of black soil, cotton and opium are also cultivated.

6.10 Humid Southern Plains (IVb)

The Districts of Dungarpur, Banswara and part of Udaipur District (Salumber block) and Pratapgarh District (Dhariyawad, Peepalkhunt, and Arnod blocks) are included in this region. The area comprises low Aravalli hills with intrusions of black lava rocks. This is mostly a tribal area where Bhils, Garasiyas and Damors live amidst forests and hills. The area has a humid climate with an average annual rainfall of more than 700 mm. The temperature regimes do not fluctuate much in summer and winter so the area has mild winters and mild summers. The humidity is always high and all these factors combined together promote a profuse growth of natural vegetation. The mountain slopes have an abundance of natural forests.

There are a number of surface water streams. Mahi and its tributaries like Anas, Arau and Jakham have made this area very fertile. The commissioning of Mahi Bajaj Sagar multipurpose project has provided this area with canal irrigation water and electricity. Cotton and sugarcane are the chief cash crops grown in the black soil region. Maize, sorghum and rice are the chief food crops of the Kharif season. Groundnut, mustard, sesamum and rapeseed are also grown. During the Rabi season, wheat, mustard and gram are the main crops.

6.11 Humid South-Eastern Plains (V)

Popularly known as the Hadauti plateau, this region includes the Districts of Baran, Bundi, Jhalawar and Kota, and Part of Sawai Madhopur District (Khandar, Sawai Madhopur blocks). The black soil region of this plateau is fertile and is used for cultivation of sugarcane, cotton and opium. The region has low hills of the Gwalior series, interspersed with broad plateaus of Vindhyan rocks. A large number of rivers drain this area. Chambal is the main river, along with its main tributaries Parvati, Kali Sindh, Parwan and Banas. The development of canal irrigation systems with a series of dams and barrages on the Chambal has made this area rich in agricultural production. Gandhi Sagar, Rana Pratap Sagar and Jawahar Sagar dams, together with Kota Barrage, generate enough electricity and canal water for irrigation.

The region has warm summers but mild winters. Summer temperatures sometimes touch 45°C. The relative humidity is generally high in this zone. The annual rainfall varies from 452 to 985 mm.

Natural vegetation exists in the form of woodlands, parklands and open forests, which have, however, now degraded. Paddy rice and sorghum are the chief food crops grown in the Kharif season. This area is also suitable for soyabean cropping. Wheat, barley, gram and mustard are grown in winter.

7. Weather

7.1 Data Used and Sources of Data

a) Rainfall data at daily intervals were provided by Water Resources Department (WRD), Jaipur for the period 1957 - 2010 (54 years) for raingauge stations maintained by Indian Meteorological Department (IMD), Water resources Department (WRD) and Revenue Department. The availability of rainfall data within this period of observation varies between the stations.

b) Data on monthly weather parameters were made available from IMD weather stations that include maximum and minimum temperature, wind speed, solar radiation, evaporation and relative humidity for the time period of 1990-2009 (20 years).

These climatic data are also required for the computation of actual evapotranspiration and consequently the crop water requirements.

Weather parameter data were collected for the past 21 years (1990 - 2010), but data for 2010 provided by IMD Pune was found insufficient in terms of number of records observed and provided (only 3 months) therefore it was discarded outright for any further analysis.

There are a total of 30 IMD stations for which data are available, but on scrutiny it was found that the availability of data for various weather parameters is different in various stations. A summary of the number of meteorological stations available and the status of data availability for various weather parameters is presented in Table 7.1.

Table 7.1 Summary of Climatological Data and their Availability, Part 1 - Temperature

S. No.	Index No.	Station Name	Maximum Temperature		Highest Maximum Temperature		Minimum Temperature		Lowest Minimum Temperature	
			Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)
1	10205	Kota PBO	Closely placed stations#	12 (11)**	Closely placed stations#	12 (11)**	Closely placed stations#	12 (11)**	Closely placed stations#	12 (11)**
2	42123	Ganganagar	Yes	19 (18)	Yes	19 (18)	Yes	19 (18)	Yes	19 (18)
3	42165	Bikaner PBO	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)
4	42170	Churu	Yes	15 (14)	Yes	15 (14)	Yes	15 (14)	Yes	15 (14)
5	42174	Pilani	Yes	20 (19)	Yes	20 (19)	Yes	20 (19)	Yes	20 (19)
6	42237	Phalodi	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)
7	42242	Nagaur	Insuf. Data	9 (7)	Insuf. Data	9 (7)	Insuf. Data	9 (7)	Insuf. Data	9 (7)
8	42249	Sikar	Insuf. Data	15 (9)	Insuf. Data	15 (9)	Insuf. Data	15 (9)	Insuf. Data	15 (9)
9	42258	Bharatpur	Insuf. Data	11 (6)	Insuf. Data	11 (6)	Insuf. Data	11 (6)	Insuf. Data	11 (6)
10	42328	Jaisalmer	Yes	16 (15)	Yes	16 (15)	Yes	16 (15)	Yes	16 (15)
11	42339	Jodhpur (a)	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)
12	42343	Ajmer	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)
13	42348	Jaipur / Sanganer	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)
14	42349	Tonk	Insuf. Data	9 (7)	Insuf. Data	9 (7)	Insuf. Data	9 (7)	Insuf. Data	9 (7)
15	42354	Dholpur	Yes	20 (17)	Yes	20 (17)	Yes	20 (17)	Yes	20 (17)
16	42435	Barmer	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)	Yes	21 (19)
17	42439	Jalore	Yes	20 (15)	Yes	20 (15)	Yes	20 (15)	Yes	20 (15)

S. No.	Index No.	Station Name	Maximum Temperature		Highest Maximum Temperature		Minimum Temperature		Lowest Minimum Temperature	
			Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)
18	42441	Jawai Bandh	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)
19	42447	Bhilwara	Insuf. Data	11 (8)	Insuf. Data	11 (8)	Insuf. Data	11 (8)	Insuf. Data	11 (8)
20	42450	Bundi	Insuf. Data	4 (3)	Insuf. Data	4 (3)	Insuf. Data	4 (3)	Insuf. Data	4 (3)
21	42452	Kota (a)	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)
22	42453	Sawai Madhopur	Yes	19 (19)	Yes	19 (19)	Yes	19 (19)	Yes	19 (19)
23	42540	Abu (Mountabu)	Yes	20 (19)	Yes	20 (19)	Yes	20 (19)	Yes	20 (19)
24	42542	Udaipur (Dabok)	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)	Yes	21 (20)
25	42543	Udaipur	Insuf. Data	7 (6)	Insuf. Data	7 (6)	Insuf. Data	7 (6)	Insuf. Data	7 (6)
26	42546	Chittorgarh	Yes	18 (16)	Yes	18 (16)	Yes	18 (16)	Yes	18 (16)
27	42552	Chambal (Rawat Bhata)	Yes	19 (14)	Yes	19 (14)	Yes	19 (14)	Yes	19 (14)
28	42555	Jhalawar	Yes	20 (16)	Yes	20 (16)	Yes	20 (16)	Yes	20 (16)
29	42655	Banswara	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)	Yes	20 (20)
30	42346	Jobner	NA		NA		NA		NA	

Yes - Considered for analysis
NA - Data not available
Insuf. Data - Insufficient data available
# Discarded due to close proximity with another station, to avoid formation of local patches
PBO – Pilot Balloon Observatory of IMD
(a) - Station with suffix (a) represents that the station is situated at Civil Aerodrome.
* - Having minimum 6 month data in a year to qualify for further processing and screening
** - Station not used due to Close proximity with Station Kota (a) inspite of qualifying for data sufficiency

Table 7.1 continued Part 2 – Wind Speed, Evaporation, Humidity and Sunshine

S. No.	Index No.	Station Name	Wind Speed		Evaporation		Relative Humidity		Sunshine Hours	
			Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)
1	10205	Kota PBO	Closely placed station#	20 (20)	Insuf. Data, but still considered##	11 (8)	Closely placed station#	19 (18)	NA	
2	42123	Ganganagar	Yes	20 (20)	Yes	19 (18)	Yes	20 (20)	Yes	15 (14)
3	42165	Bikaner PBO	Yes	20 (20)	Yes	17 (15)	Yes	20 (20)	Yes	19 (15)
4	42170	Churu	Yes	20 (20)	Yes	15 (14)	Yes	20 (20)	NA	
5	42174	Pilani	Yes	20 (18)	NA		Yes	20 (18)	NA	
6	42237	Phalodi	Yes	18 (17)	NA		Yes	18 (17)	NA	
7	42242	Nagaur	NA		NA		Insuf. Data	7 (6)	NA	
8	42249	Sikar	Insuf. Data	3 (3)	NA		Insuf. Data	13 (8)	NA	
9	42258	Bharatpur	Outliers	15 (10)	NA		Insuf. Data	15 (9)	NA	
10	42328	Jaisalmer	Yes	18 (18)	Yes	16 (15)	Yes	18 (18)	NA	
11	42339	Jodhpur (a)	Yes	20 (18)	Yes	12 (12)	Yes	20 (19)	Insuf. Data	6 (5)
12	42343	Ajmer	Yes	20 (20)	NA		Yes	20 (20)	NA	
13	42348	Jaipur / Sanganer	Yes	19 (19)	Yes	15 (14)	Yes	19 (19)	Yes	18 (17)
14	42349	Tonk	NA		NA		Insuf. Data	11 (5)	NA	
15	42354	Dholpur	Outliers	20 (15)	NA		Yes	20 (17)	NA	16 (15)
16	42435	Barmer	Yes	19 (19)	Yes	16 (14)	Yes	19 (19)	Yes	
17	42439	Jalore	Yes	16 (11)	NA		Yes	19 (15)	NA	
18	42441	Jawai Bandh	Yes	20 (19)	Yes	11 (10)	Yes	20 (19)	NA	

S. No.	Index No.	Station Name	Wind Speed		Evaporation		Relative Humidity		Sunshine Hours	
			Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)	Data Status	Total number of years (No. of Years with Sufficient Data*)
19	42447	Bhilwara	Insuf. Data	6 (3)	NA		Insuf. Data	13 (10)	NA	
20	42450	Bundi	Outliers	6 (0)	NA		Insuf. Data	7 (3)	NA	
21	42452	Kota (a)	Yes	19 (19)	NA		Yes	19 (19)	NA	
22	42453	Sawai Madhopur	Yes	17 (15)	NA		Yes	20 (19)	NA	
23	42540	Abu (Mount Abu)	Outliers	18 (14)	NA		Yes	20 (17)	NA	
24	42542	Udaipur (Dabok)	Yes	19 (19)	Insuf. Data		Yes	19 (19)	NA	
25	42543	Udaipur	Insuf. Data	9 (0)	Yes	16(16)	Insuf. Data	9 (0)	Yes	15 (14)
26	42546	Chittorgarh	Yes	19 (17)	Outliers	10 (10)	Yes	19 (17)	NA	
27	42552	Chambal (Rawat Bhata)	Outliers	19 (11)	Yes	17 (14)	Yes	19 (11)	NA	
28	42555	Jhalawar	Yes	20 (19)	NA		Yes	20 (19)	NA	
29	42655	Banswara	Outliers	20 (19)	Yes	11 (11)	Yes	20 (20)	NA	
30	42346	Jobner	Closely placed stations#	15 (15)	Closely placed stations#	15 (15)	NA		NA	

Yes - Considered for analysis
NA - Data not available
Outliers - Data available but discarded due to abnormal values
Insuf. Data - Insufficient data available
# Discarded due to close proximity with another station, to avoid formation of local patches
## Station considered for analysis inspite of less data availability
PBO – Pilot Balloon Observatory of IMD
(a) - Station with suffix (a) represents that the station is situated at Civil Aerodrome.
* - Having minimum 6 month data in a year to qualify for further processing and screening

The criteria adopted for scrutinizing the raw weather data were:

- ✓ Sufficiency of data, i.e. years with data for more than any 6 months with a total number of years exceeding 10
- ✓ Discontinuity in time series data
- ✓ Number of outlying values

A summary of parameter availability and number of stations is presented in Table 7.2.

Table 7.2 Status of Meteorological Data Availability for Various Parameters

Parameter	No. of Stations	Discarded	Stations Considered for Analysis
Mean Maximum Temperature	29	8	21
Highest Maximum Temperature	29	8	21
Mean Minimum Temperature	29	8	21
Lowest Minimum Temperature	29	8	21
Wind Speed	28	11	17
Evaporation	15	3	12
Relative Humidity	29	8	21
Sunshine Hours	6	1	5

All the data were then scrutinized for outliers (abnormal values). Outliers, wherever encountered, were first compared with the respective IMD normal climatic values, and potential suspected values were discarded from the analysis.

An analysis was performed on these scrutinized data sets and the results are discussed in the respective weather parameter sections. These data have also been used to analyse the trends, if any, in the data.

7.2 Trend Analysis Methodology

A climate time series is generally not statistically independent but is comprised of patterns of persistence, cycles, trends or other non random components. Mann-Kendall test is used to test for trends over time. This test is non-parametric. It has been widely used to test for randomness against trend in hydrology and climatology (e.g. Burn and Elnur, 2002[1] ; Zhang et al., 2000[2] ; Xu et al., 2003[3] ; Partal and Kalya, 2006[4] and Obot et al., 2010[5]).

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[1] Burn, D.H. and M.A. Hag Elnur. 2002. “Detection. Of Hydrologic Trends and Variability. Journal of Hydrology 255 (2002), 107-122.

[2] Zhang, J. L., et al. (2000), Recent changes in Arctic sea ice: The interplay between ice dynamics and thermodynamics, J. Clim., 13, 3099–3114.

The non-parametric trend statistic, Kendall’s Tau, is calculated for monotonic trends, making no assumptions about the distribution of the data or the linearity of any trends (Hollander and Wolfe, 1973[6]),

The non-parametric trend statistic, Kendall’s Tau, is calculated for monotonic trends, making no assumptions about the distribution of the data or the linearity of any trends (Hollander and Wolfe, 1973), the statistic is also robust in the face of outliers. The Mann Kendall test has two parameters that are of importance for trend detection: the significance level that indicates the test strength (p) and the value of Tau that indicates the direction as well as the strength of the trend. Kendall’s Tau is a measure of correlation; it measures the strength of association between two variables. Kendall’s Tau will take values between +1 and -1. A positive correlation indicates that ranks of both the variables increase together while a negative correlation indicates that as the rank of one variable increases the other one decreases.

Trend tests are run at 10% level of significance to indicate the presence of statistically significant trends over the period of available data.

In this present study a trend is considered statistically significant when its Confidence level is greater than or equal to 90%.

A detailed description of trend analysis using Mann Kendall statistics is presented in Appendix 5 (Volume 2 of this report).

7.3 Temperature Statistics

Data on maximum and minimum temperature for Rajasthan have been analysed. The observed temperatures for the period 1990-2009 show a large temporal variability, as shown in Table 7.3.

Table 7.3 Maximum and Minimum Temperature Statistics in Rajasthan

Season	Statistics	Maximum Temperature, °C	Minimum Temperature, °C	Highest Maximum Temperature, °C	Lowest Minimum Temperature, °C
Annual	Mean	33.2	19.1	45.2	3.3
	Spatial Range	25.7 - 35.0	11.8 - 21.8	43.2 -46.8	1.6 - 6.1
Cold Weather (Dec. – Jan. – Feb.)	Mean	25.7	9.6	34.6	1.2
	Spatial Range	19.7 - 30.3	3.1 - 14.7	29.0 - 39.2	-7.4 - 6.7
Pre Monsoon (Mar. – Apr. – May)	Mean	37.4	21.5	44.7	12.1
	Spatial Range	26.5 - 43.4	10.3 - 30.0	34.6 - 49.9	0.6 - 21.0

---

[3] Xu ZX, Takeuchi K, Ishidaira H (2003). Monotonic trend and step changes in Japanese Rainfall. J. Hydrol., 279: 144-150.

[4] Partal T, Kahya E (2006). Trend analysis in Turkish Rainfall data. Hydrol. Proc., 20: 2011-2026.

[5] Obot NI, Chendo MAC, Udo, SO., Ewona, IO., (2010). Evaluation of rainfall trends in Nigeria for 30 years (1978-2007). J. Phy. Sci.,5(14): pp. 2217-2222.

[6] Myles Hollander and Douglas A. Wolfe (1973), Nonparametric Statistical Methods. New York: John Wiley & Sons.

Season	Statistics	Maximum Temperature, °C	Minimum Temperature, °C	Highest Maximum Temperature, °C	Lowest Minimum Temperature, °C
Monsoon (Jun. – Jul. – Aug. – Sep.)	Mean	35.5	25.1	43.1	17.8
	Spatial Range	23.5 - 42.0	15.6 - 29.5	31.6 - 50.0	6.4 - 22.2
Post Monsoon (Oct. – Nov.)	Mean	32.6	16.4	39.2	8.2
	Spatial Range	24.4 - 37.1	7.0 - 22.5	38.0 - 46.8	4.4 - 16.6

Source: IMD monthly temperature data (1990 - 2009)

It is evident from Table 7.3 that the maximum temperature is highest in (37.4°C) the pre-monsoon season, while it is lowest (25.7°C) in cold weather season. Mean annual maximum temperature in Rajasthan is 33.2°C with a range of 25.7°C - 35.0°C.

Minimum temperature attains its Mean highest value (25.1°C) during monsoon season, while it attains its Mean lowest value (9.6°C) in cold weather season. Mean annual Minimum temperature within Rajasthan is 19.1°C with a range of 11.8°C - 21.8°C.

Highest Maximum temperature attains its maximum value during Pre-Monsoon season (44.7°C) while it is lowest during Cold Weather season (34.6°C)

Lowest Minimum temperature attains it lowest value during Cold weather (1.2°C) while it is highest during Monsoon season (17.8°C).

Figure 7.1 and Figure 7.2 show the variation of Mean Annual Daily Maximum and Minimum temperature in Rajasthan, respectively.

Table 7.4 shows mean daily maximum and minimum temperatures per year for the period 1990 to 2009.

From Table 7.4 it can be observed that the mean daily maximum and mean daily minimum temperatures within the study period in Rajasthan are 33.2°C and 19.1°C respectively. Both maximum and minimum temperatures show an increasing trend within the study period of 20 years, as reflected by their positive trend and statistically significant confidence level. Within the study period of 20 years (1990 - 2009) the Maximum temperature has increased by 0.78°C, with per year increase of 0.04°C, while the minimum temperature has increased by 1.14°C with per year increase of 0.06°C.

These increasing trends in temperature shall have varied impacts on the already stressed water resources of the state.

Table 7.4 Mean Daily Maximum and Minimum Temperatures per Year, °C

Year	Mean Maximum	Mean Minimum
1990	32.7	18.5
1991	33.2	19.3

Year	Mean Maximum	Mean Minimum
1992	32.8	18.8
1993	33.7	19.0
1994	32.9	18.4
1995	33.4	19.2
1996	33.1	18.3
1997	31.3	18.5
1998	33.1	19.3
1999	33.4	18.7
2000	33.7	18.7
2001	32.9	18.9
2002	34.3	20.0
2003	32.7	18.5
2004	34.3	20.2
2005	33.1	18.8
2006	33.6	19.7
2007	33.3	19.5
2008	33.2	19.4
2009	34.2	20.2
Mean	33.2	19.1
Positive (P) or Negative (N) trend	P	P
Confidence Level, %	91.0	98.0
Temperature increase, °C (1990-2009)	0.8	1.1
Incremental change per year, °C	0.04	0.06

Source: IMD Monthly dataset (1990-2009)

Table 7.5 shows that the mean daily minimum temperature by months ranges between 8.2°C in January and 27.0°C in June while mean daily maximum temperature by months ranges between 24.0°C in January and 41.1°C in May.

Table 7.5 Mean Daily Maximum and Minimum Temperatures by Months, °C

Month	Mean Maximum	Mean Minimum
January	24.0	8.2
February	27.3	11.2
March	32.9	16.5
April	38.3	21.9
May	41.1	26.2
June	39.5	27.0
July	34.8	25.6
August	33.2	24.5

Month	Mean Maximum	Mean Minimum
September	34.4	23.4
October	34.6	19.1
November	30.5	13.6
December	25.9	9.3
Monthly Mean	33.0	18.9

Source: IMD Monthly dataset (1990-2009)

Table 7.6 shows the mean daily highest maximum and lowest minimum temperatures during the 20 years period from 1990 to 2009. Highest maximum temperatures range between 43.2°C to 46.8°C, while the lowest minimum temperature ranges between 1.6°C to 6.1°C within the study period. Mean highest maximum temperature and mean lowest minimum temperature is 45.2°C and 3.3°C, respectively. Figure 7.3 and Figure 7.4 show the Mean Daily Highest Maximum and Mean Daily Lowest Minimum Temperature of Rajasthan, respectively. Table 7.7 shows the mean daily highest maximum and lowest minimum temperatures by months.

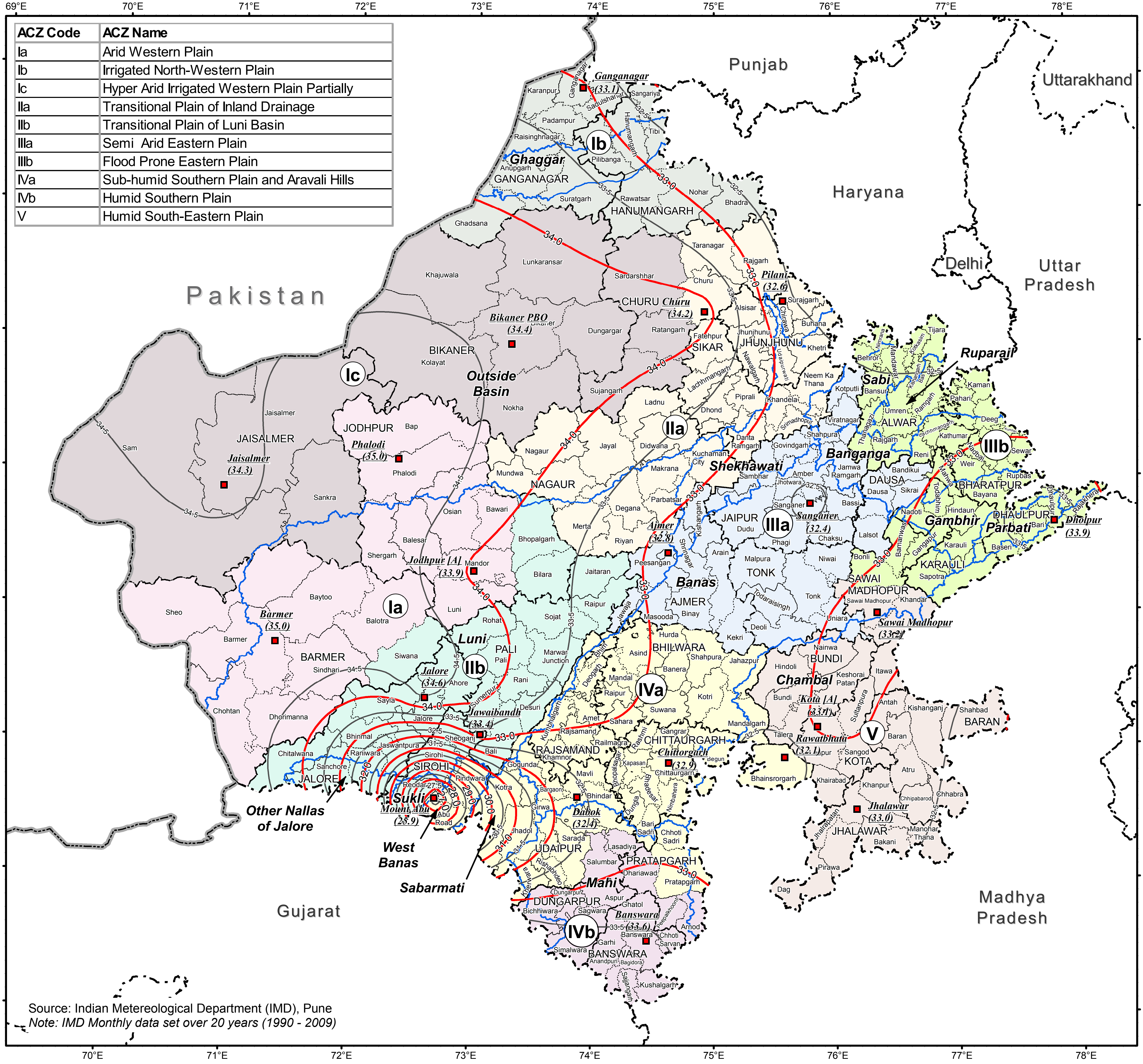
Table 7.6 Mean Daily Highest Maximum and Lowest Minimum Temperatures by year, °C

Year	Highest Max.	Lowest Min.
1990	44.2	1.7
1991	45.8	1.6
1992	45.7	3.2
1993	45.4	4.1
1994	46.7	2.7
1995	46.4	3.9
1996	44.9	3.5
1997	43.2	3.4
1998	46.8	3.2
1999	45.1	3.7
2000	44.6	2.0
2001	45.4	3.1
2002	45.8	4.0
2003	45.4	3.2
2004	45.2	4.4
2005	44.9	3.1
2006	45.4	3.3
2007	44.6	3.9
2008	43.6	2.2
2009	45.6	6.1
Mean	45.2	3.3
Positive (P) or Negative (N) trend	N	P
Confidence Level, %	70.0#	81.0#

Source: IMD Monthly dataset (1990 - 2009)

# indicates insignificant trend, as the confidence level is less than 90%.

Figure 7.1



ACZ Code	ACZ Name
Ia	Arid Western Plain
Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
IIa	Transitional Plain of Inland Drainage
IIb	Transitional Plain of Luni Basin
IIIa	Semi Arid Eastern Plain
IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE

RAJASTHAN

Legend

■ Station Location

Maximum Temperature (°C)

— Index Isoline (1.0°C)

— Intermediate Isoline (0.5°C)

Boundaries

Block

District

Agro Climatic Zone

River Basin

State

International

Labels

Block
DISTRICT
State
Country

Station Name (Mean Value)
Index Isoline
Intermediate Isoline
River Basin
ACZ

N
E
S
W

0 50 100 150 200 Km

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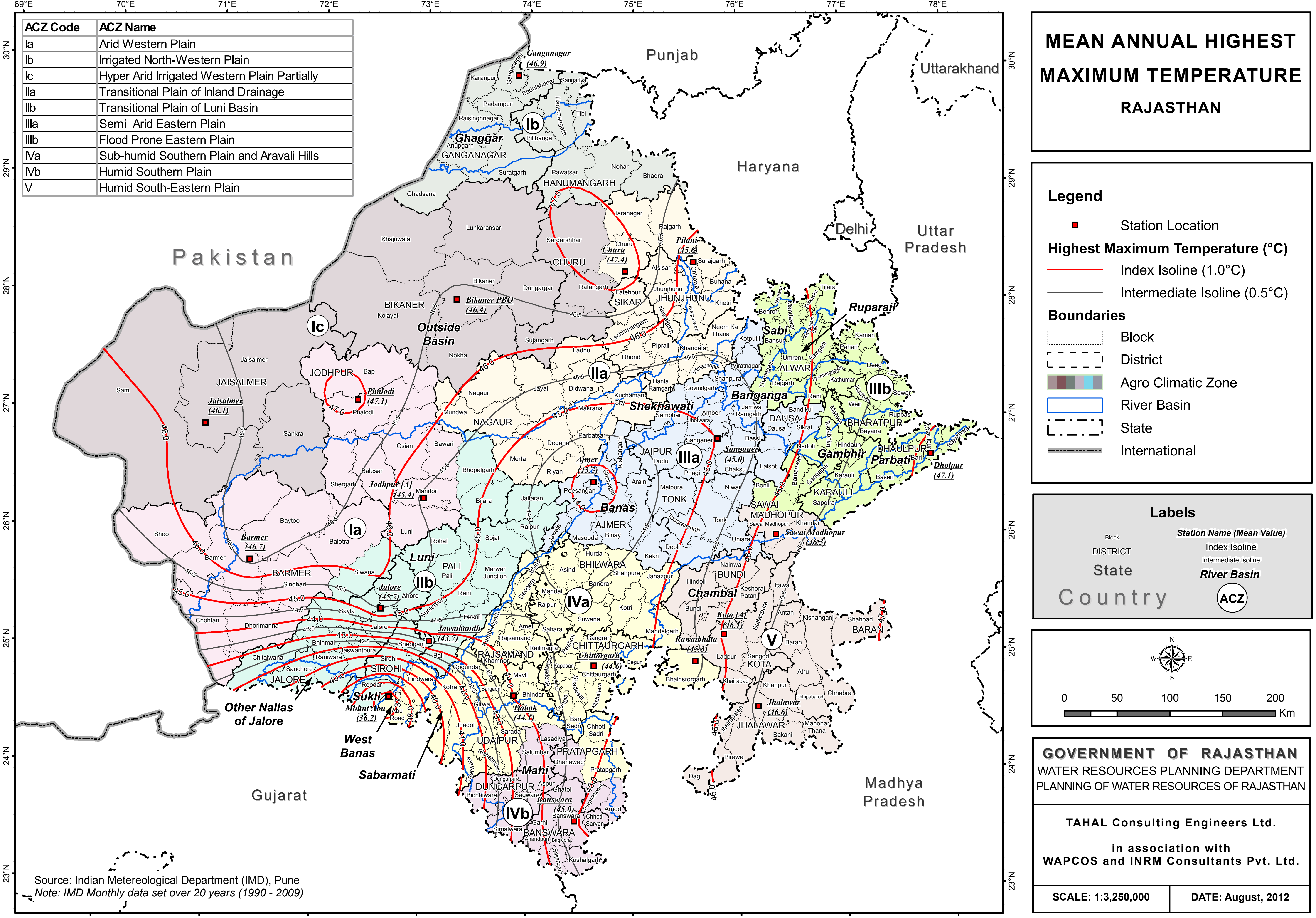
Figure 7.3

MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE

RAJASTHAN



ACZ Code	ACZ Name
Ia	Arid Western Plain
Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
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IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

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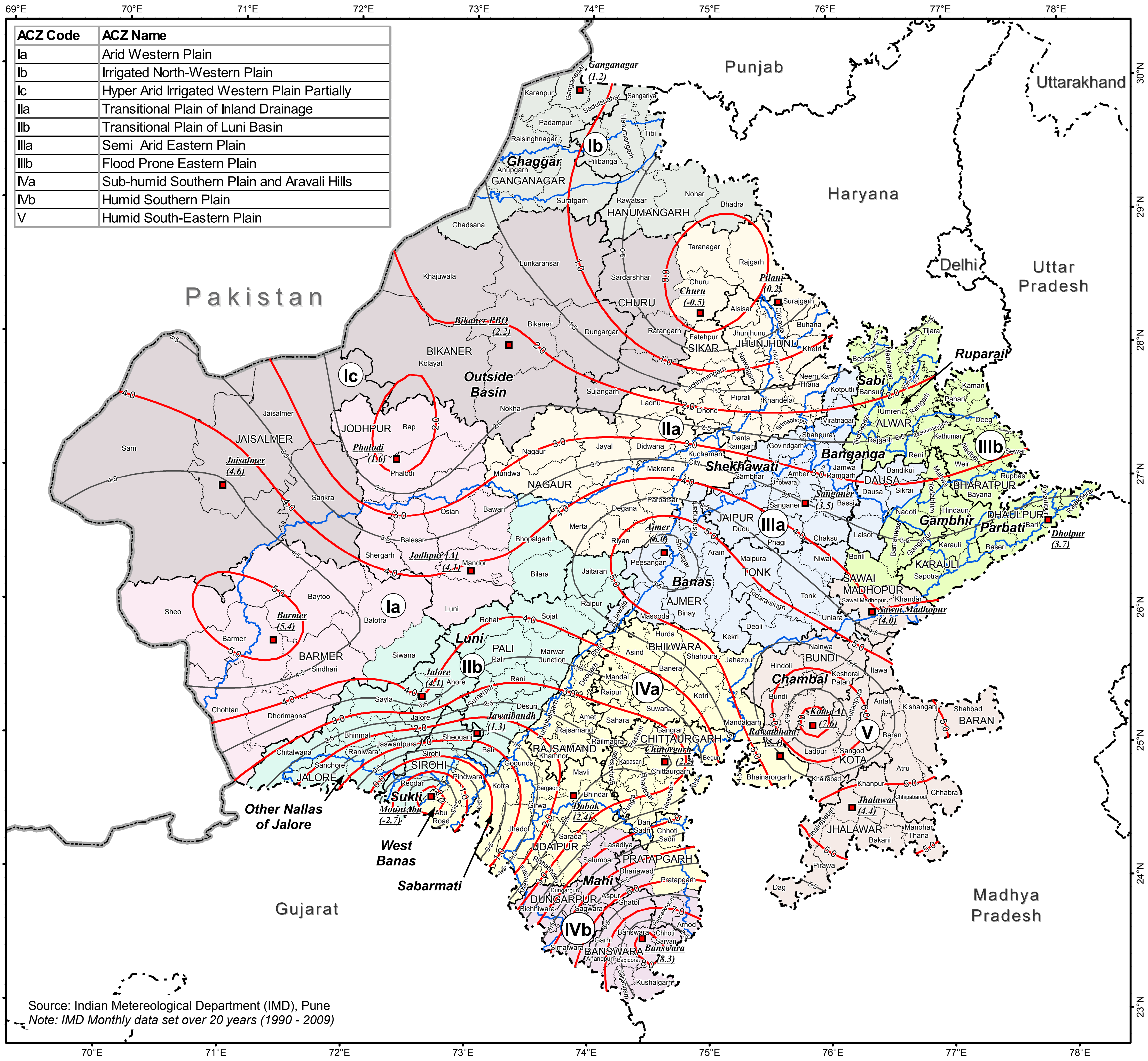
Figure 7.4



ACZ Code	ACZ Name
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Ic	Hyper Arid Irrigated Western Plain Partially
IIa	Transitional Plain of Inland Drainage
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IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL LOWEST MINIMUM TEMPERATURE

RAJASTHAN

Legend

🟥	Station Location

Lowest Minimum Temperature (°C)

—	Index Isoline (1.0°C)
—	Intermediate Isoline (0.5°C)

Boundaries

┈	Block
╌	District
▨	Agro Climatic Zone
▭	River Basin
─·─	State
─·─	International

Labels

Block
DISTRICT
State
Country
Station Name (Mean Value)
Index Isoline
Intermediate Isoline
River Basin
ACZ

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Table 7.7 Mean Daily Highest Maximum and Lowest Minimum Temperatures by Months, °C

Month	Highest Max.	Lowest Min.
January	33.2	0.3
February	36.7	2.1
March	41.6	6.7
April	45.1	12.1
May	47.5	17.6
June	47.2	17.6
July	43.8	18.2
August	40.4	19.1
September	41.0	16.3
October	40.8	10.9
November	37.5	5.4
December	34.0	1.2
Monthly Mean	40.7	10.6

Source: IMD Monthly dataset (1990 - 2009)

Figure 7.5 and Figure 7.6 show temperature variations over 20 years (1990-2009) while Figure 7.7 and Figure 7.8 show temperature variation during the months based on 20 years data (1990-2009).

Figure 7.5 Mean Daily Maximum and Minimum Temperatures per Year, °C

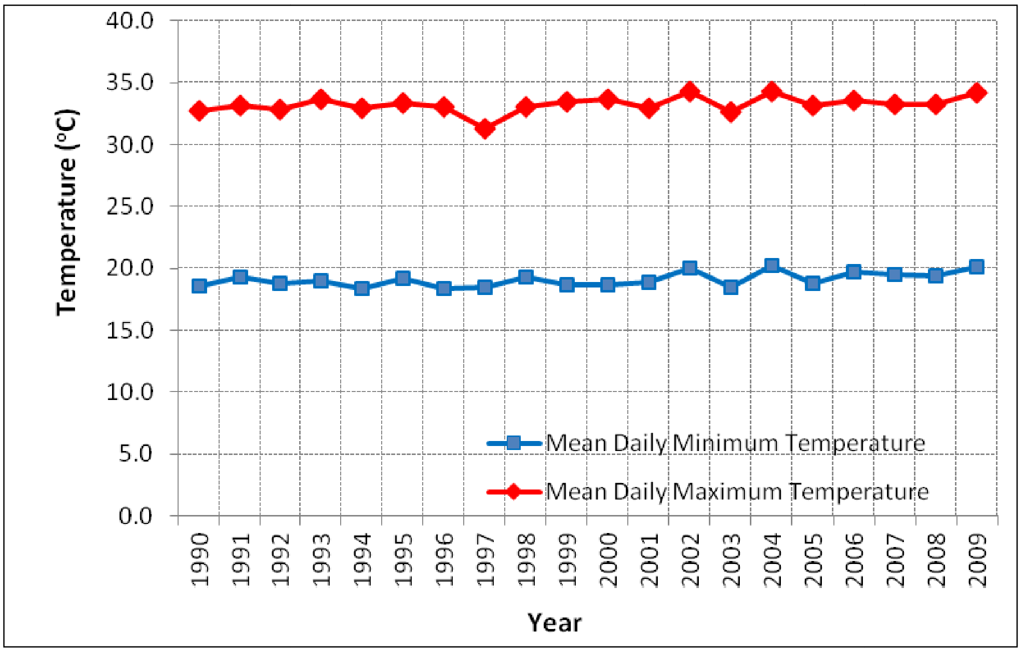


Figure 7.6 Mean Daily Highest Maximum and Lowest Minimum Temperatures per Year, °C

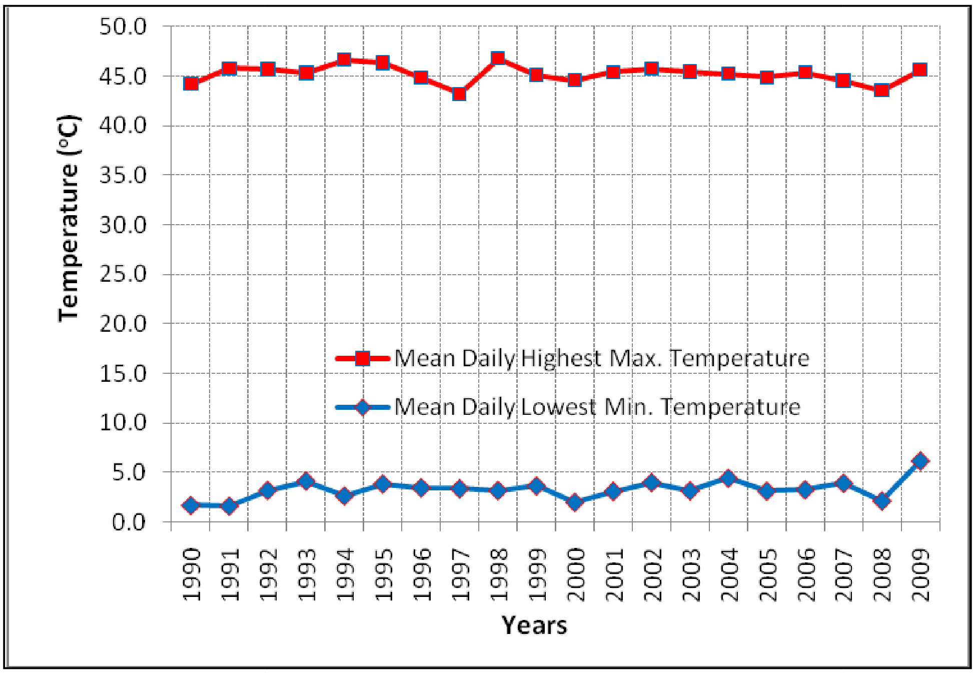


Figure 7.7 Mean Daily Maximum and Minimum Temperature per Month, °C

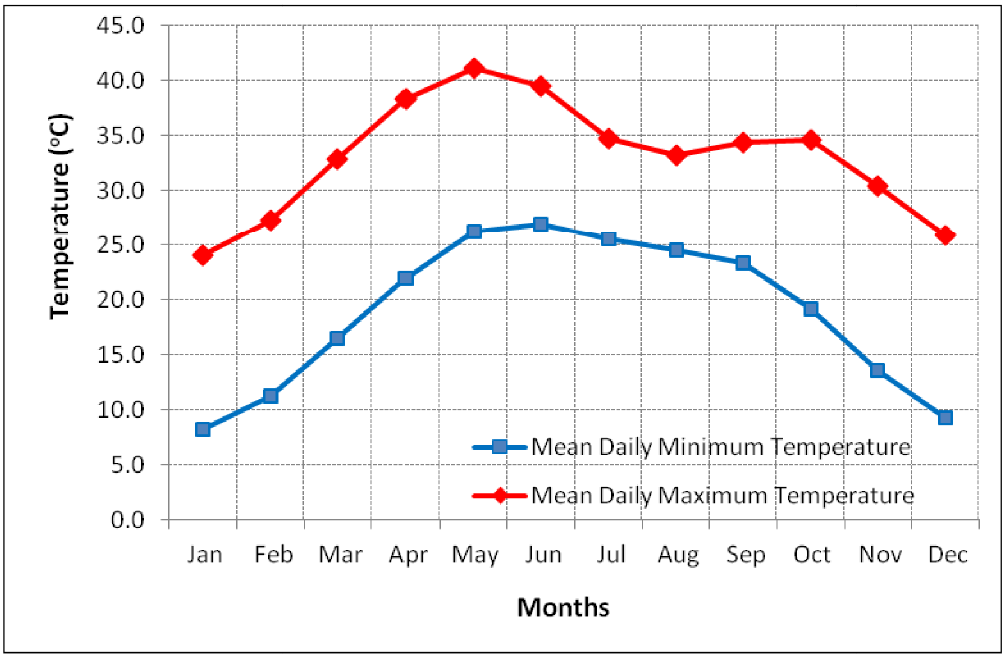
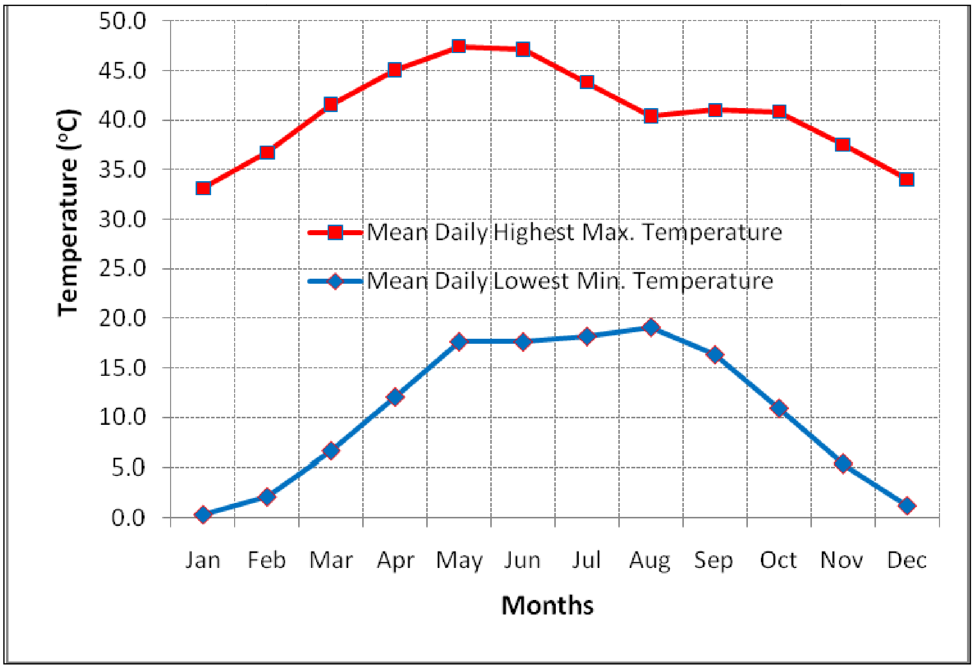


Figure 7.8 Mean Daily Highest Maximum and Lowest Minimum Temperature per Month, °C



7.4 Rainfall Statistics

7.4.1 Data

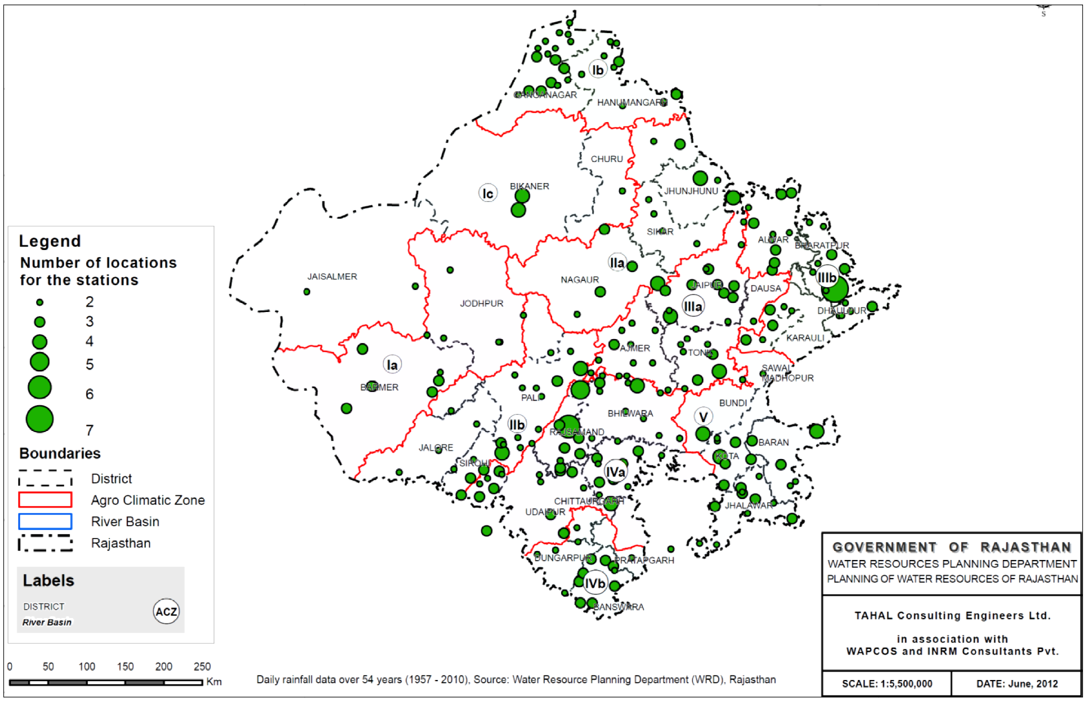
The rainfall data was found to have numerous weaknesses, such as large missing records, no rainfall data in rainfall months, stations with same name but with different locations, same locations with different names, miss-spelt station names, duplicated station, etc. Figure 7.9 shows stations with more than one Latitude/Longitude.

After scrutinizing the rainfall data in terms of location and rainfall values, a total of 542 stations were retained for further analysis.

These raingauge stations comprise stations maintained by various agencies, including IMD (16), WRD (209) and Revenue department (317).

Of these 542 stations, only those raingauge stations were considered for further analysis for which 30 years or more data are available, which is essential for any hydrological and statistical analysis. It is very usual to have missing records in rainfall data. Missing rainfall records are in-filled to generate rainfall series. Infilling for the target station is performed by considering the observations of the neighbouring stations (base stations) during the period in question. In the present study only those base stations were selected which are within 30 km radius of the target station. After all the scrutiny only 327 raingauge stations which had 30 years or more of data could qualify to be considered for further analysis. Figure 7.10 shows the 542 raingauge stations across the State maintained by different authorities as mentioned above and also their status i.e. if they qualified to be included in the list of 327 stations for further analysis or not.

Figure 7.9 Stations with More Than One Latitude and Longitude Values



Daily rainfall data over 54 years (1957 - 2010). Source: Water Resource Planning Department (WRD), Rajasthan

7.4.2 Rainfall Double-Mass Curve Analysis

Double-mass curve analysis was performed to check and correct inconsistencies in rainfall dataset which may result from a variety of causes, including changes in type of instrument, changes in observation procedures, and/or changes in gauge location or surrounding conditions.

As an example, a double-mass curve analysis for Station Mansarowar (WRIS Code 21) is presented in Figure. 7.11, which is a plot of Cumulated rainfall of Target station to Cumulated rainfall of Base stations.

The tabular output from the double-mass curve is shown in Table 7.8.

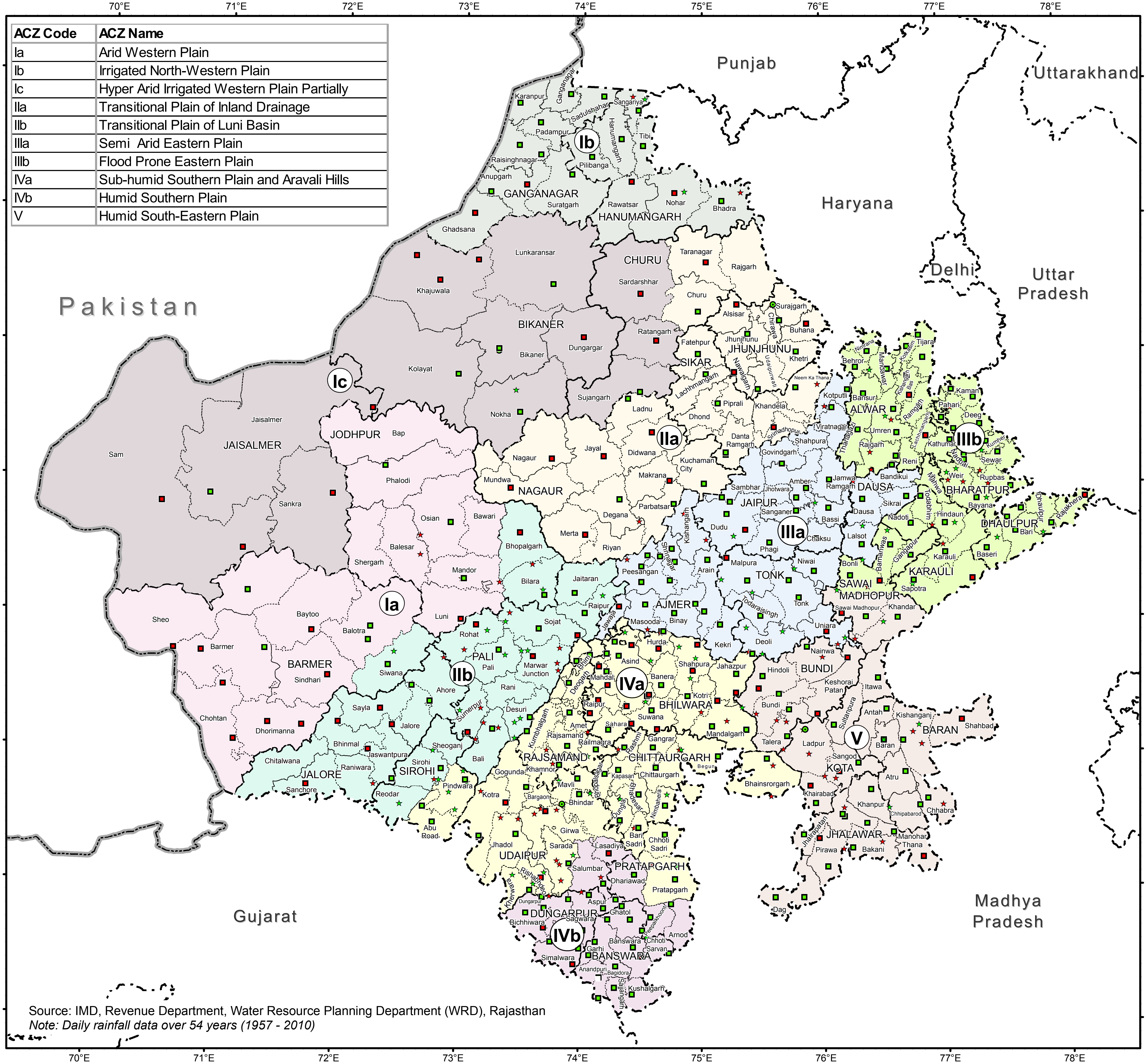
It is apparent from Table 7.8 that after year 1991 (break point) there is a change in trend of rainfall received at Mansarowar station. In this particular case, there is a reduction in rainfall capture at the target station in comparison with the base stations which is reflected by the corresponding value in "Rat_Per" (Ratio Percentage) column.

It can be seen that in Mansarowar station for instance all the rainfall values after the year 1991 had to be increased by a factor to correct the rainfall data due to improper exposure conditions and thus to make it consistent with respect to the previous conditions. This is done by carrying out data series transformation using linear algebraic option. It is evident from the correlation values (R^2) shown in the plots that it increases from 0.9928 to 0.9974.

The double-mass curve after data series adjustment is shown in Figure 7.11 and the corresponding tabular analysis of the results is presented in Table 7.8. It may be noted that the double-mass curve after the data series adjustment beyond 1991 shows a consistent trend throughout.

Figure 7.10

RAINFALL STATIONS STATUS
RAJASTHAN



ACZ Code	ACZ Name
Ia	Arid Western Plain
Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
IIa	Transitional Plain of Inland Drainage
IIb	Transitional Plain of Luni Basin
IIIa	Semi Arid Eastern Plain
IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: IMD, Revenue Department, Water Resource Planning Department (WRD), Rajasthan

Note: Daily rainfall data over 54 years (1957 - 2010)

Legend

Raingauge Stations

Stations Used

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Stations Not Used

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Boundaries

- Block
- District
- Agro Climatic Zone
- State
- International

Labels

DISTRICT
State
Country
Block
ACZ

0 50 100 150 200 Km

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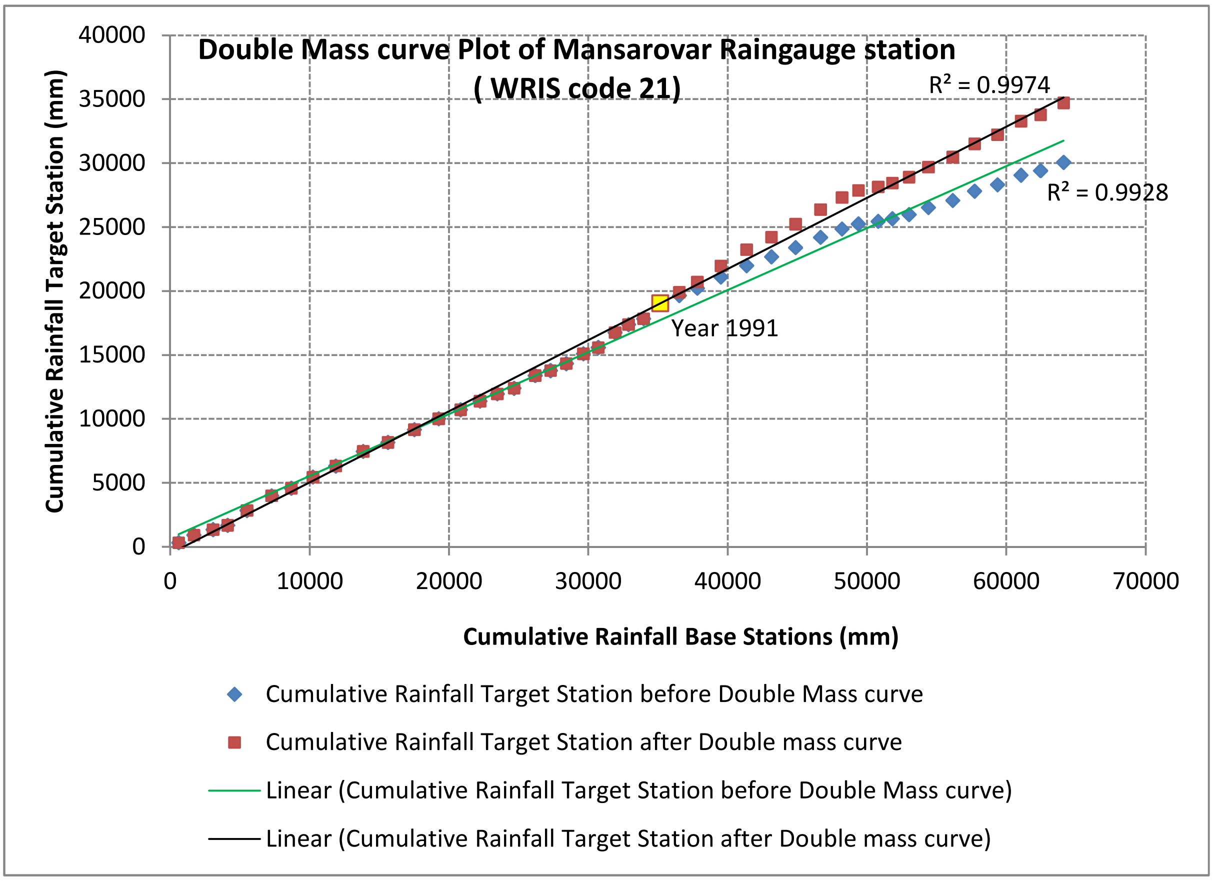
Figure 7.11 Mansarowar Station - Double-Mass Plot before and after Adjusting Rainfall Values for the Period of Inconsistency



Source: WRD (Water Resource Department) data

The same procedure was applied to other stations too. As there are ~327 stations for which output is generated, it is too voluminous to present all the results for all the stations under study in this report. They are however available as a separate digital file.

Although a correlation of 0.90 is sufficient for a station to be called consistent. Only those stations whose correlation is below 0.90 were corrected and the results are available separately as a soft copy.

Index of Target Stations and their respective Base stations are presented in Appendix 6 (Volume 2 of this report).

Table 7.8 Results of Double-Mass Curve Analysis for Mansarowar Station

Year	B_mm, mm	T_mm, mm	B_cum, mm	T_Cum, mm	B_Per	T_Per	Rat_Cum	Rat_Per	Test	Counter	New Target
1966	591.3	330.9	591.3	330.9	0.9	1.1	0.6	1.2			330.9
1967	1097.3	598.7	1688.6	929.6	2.6	3.1	0.6	1.2		1	929.6
1968	1376.3	425.9	3064.9	1355.5	4.8	4.5	0.4	0.9		2	1355.5
1969	1040.7	336.0	4105.5	1691.5	6.4	5.6	0.4	0.9		3	1691.5
1970	1388.4	1162.4	5493.9	2853.9	8.6	9.5	0.5	1.1		0	2853.9
1971	1767.8	1148.5	7261.7	4002.4	11.3	13.3	0.6	1.2		0	4002.4
1972	1413.6	590.0	8675.3	4592.4	13.5	15.3	0.5	1.1		1	4592.4
1973	1548.5	868.0	10223.8	5460.4	16.0	18.2	0.5	1.1		0	5460.4
1974	1641.9	870.5	11865.7	6330.8	18.5	21.1	0.5	1.1		1	6330.8
1975	1963.5	1140.3	13829.2	7471.1	21.6	24.8	0.5	1.2		0	7471.1
1976	1781.7	702.0	15610.9	8173.1	24.4	27.2	0.5	1.1		1	8173.1
1977	1894.4	997.9	17505.2	9171.0	27.3	30.5	0.5	1.1		0	9171.0
1978	1744.4	852.0	19249.6	10023.0	30.0	33.3	0.5	1.1		1	10023.0
1979	1577.0	706.3	20826.6	10729.3	32.5	35.7	0.5	1.1		2	10729.3
1980	1394.6	668.0	22221.2	11397.3	34.7	37.9	0.5	1.1		3	11397.3
1981	1240.3	569.0	23461.4	11966.3	36.6	39.8	0.5	1.1		4	11966.3
1982	1201.1	446.0	24662.6	12412.3	38.5	41.3	0.5	1.1		5	12412.3
1983	1517.3	985.5	26179.8	13397.8	40.8	44.6	0.5	1.1		0	13397.8
1984	1101.1	392.6	27281.0	13790.4	42.6	45.9	0.5	1.1		1	13790.4
1985	1129.1	549.6	28410.0	14340.0	44.3	47.7	0.5	1.1		2	14340.0
1986	1233.0	766.0	29643.1	15106.0	46.2	50.2	0.5	1.1		0	15106.0
1987	1063.0	487.0	30706.1	15593.0	47.9	51.8	0.5	1.1		1	15593.0
1988	1211.0	1171.6	31917.1	16764.6	49.8	55.7	0.5	1.1		0	16764.6
1989	955.5	625.0	32872.6	17389.6	51.3	57.8	0.5	1.1		0	17389.6
1990	1084.8	457.0	33957.4	17846.6	53.0	59.3	0.5	1.1		1	17846.6
1991	1195.4	1196.0	35152.7	19042.6	54.8	63.3	0.5	1.2		0	19042.6
1992	1370.2	619.2	36522.9	19661.8	57.0	65.4	0.5	1.2	880.2	1	19922.8
1993	1294.1	562.5	37817.0	20224.3	59.0	67.2	0.5	1.1	799.7	2	20722.4
1994	1687.1	883.0	39504.1	21107.3	61.6	70.2	0.5	1.1	1255.2	3	21977.7
1995	1845.5	891.0	41349.6	21998.3	64.5	73.1	0.5	1.1	1266.6	4	23244.3
1996	1787.3	690.0	43136.8	22688.3	67.3	75.4	0.5	1.1	980.9	5	24225.2
1997	1737.1	715.1	44874.0	23403.3	70.0	77.8	0.5	1.1	1016.5	6	25241.7
1998	1789.3	800.9	46663.3	24204.3	72.8	80.5	0.5	1.1	1138.6	7	26380.2

Year	B_mm, mm	T_mm, mm	B_cum, mm	T_Cum, mm	B_Per	T_Per	Rat_Cum	Rat_Per	Test	Counter	New Target
1999	1538.7	663.5	48201.9	24867.8	75.2	82.7	0.5	1.1	943.2	8	27323.5
2000	1176.3	388.0	49378.3	25255.8	77.0	84.0	0.5	1.1	551.6	9	27875.0
2001	1416.2	197.0	50794.4	25452.8	79.2	84.6	0.5	1.1	280.1	10	28155.1
2002	1019.1	209.0	51813.5	25661.8	80.8	85.3	0.5	1.1	297.1	11	28452.2
2003	1198.5	332.0	53012.1	25993.8	82.7	86.4	0.5	1.1	472.0	12	28924.1
2004	1386.3	546.0	54398.3	26539.8	84.9	88.2	0.5	1.0	776.2	13	29700.3
2005	1744.6	554.0	56143.0	27093.8	87.6	90.1	0.5	1.0	787.5	14	30487.8
2006	1576.3	730.0	57719.3	27823.8	90.0	92.5	0.5	1.0	1037.7	15	31525.6
2007	1638.7	500.0	59357.9	28323.8	92.6	94.2	0.5	1.0	710.8	16	32236.3
2008	1691.3	745.0	61049.3	29068.8	95.2	96.7	0.5	1.0	1059.1	17	33295.4
2009	1403.7	349.0	62452.9	29417.8	97.4	97.8	0.5	1.0	496.1	18	33791.5
2010	1655.8	659.0	64108.8	30076.8	100.0	100.0	0.5	1.0	936.8	19	34728.3

Corelation (R^2): 0.99

Table 7.8 shows the results of double-mass-curve analysis for Mansarowar station, where:

B_mm : Sum of annual rainfall of base stations, mm

T_mm : Sum of annual rainfall of target station, mm

B_Cum : Cumulative rainfall of base stations, mm

T_Cum : Cumulative rainfall of Target station, mm

B_Per : Ratio of cumulative base value to Total cumulative value.

T_Per : Ratio of cumulative target value to Total cumulative value.

Rat_cum : Target cumulative to base cumulative

Rat_per : T_Per to B_per

New Target : New Cumulative target station values

The highlighted field in Table 7.8 is the break point from which values for later years are adjusted. Year 1991 is the breakpoint in this case.

Rainfall in the state of Rajasthan varies considerably from year to year, both in space and in time. Table 7.9 gives the summary of observed rainfall statistics in Rajasthan.

Table 7.9 Rainfall Statistics in Rajasthan

Season	Statistics	Value	Contribution to Annual Rainfall, %
Annual	Mean, mm	495.60	
	Inter-annual variation, CV*	0.40	
	Spatial Range, mm	244.00 - 782.80	
Cold Weather (December -January-February)	Mean, mm	10.90	2.20
	Inter-annual variation, CV*	0.50	
	Spatial Range, mm	3.60 - 17.90	
Pre-Monsoon (March-April-May)	Mean, mm	16.90	3.40
	Inter-annual variation, CV*	0.45	
	Spatial Range, mm	6.80 - 29.20	
Monsoon (June-July-August-September - JJAS)	Mean, mm	454.00	91.60
	Inter-annual variation, CV*	0.44	
	Spatial Range, mm	200.60 - 744.80	
Post Monsoon (October-November)	Mean, mm	13.80	2.80
	Inter-annual variation, CV*	0.54	
	Spatial Range, mm	4.30 - 26.20	

* CV - Coefficient of Variation[7]

Table 7.9 shows rainfall statistics of Rajasthan over various seasons. Form this table it can be observed that the monsoon season (June, July, August and September - JJAS) mean rainfall (454 mm) is maximum amongst all 4 seasons and contributes 91.6% of the annual rainfall (495.6 mm). Figure 7.12 and 7.13 show observed rainfall in the monsoon season and the variation of mean annual rainfall across Rajasthan, respectively.

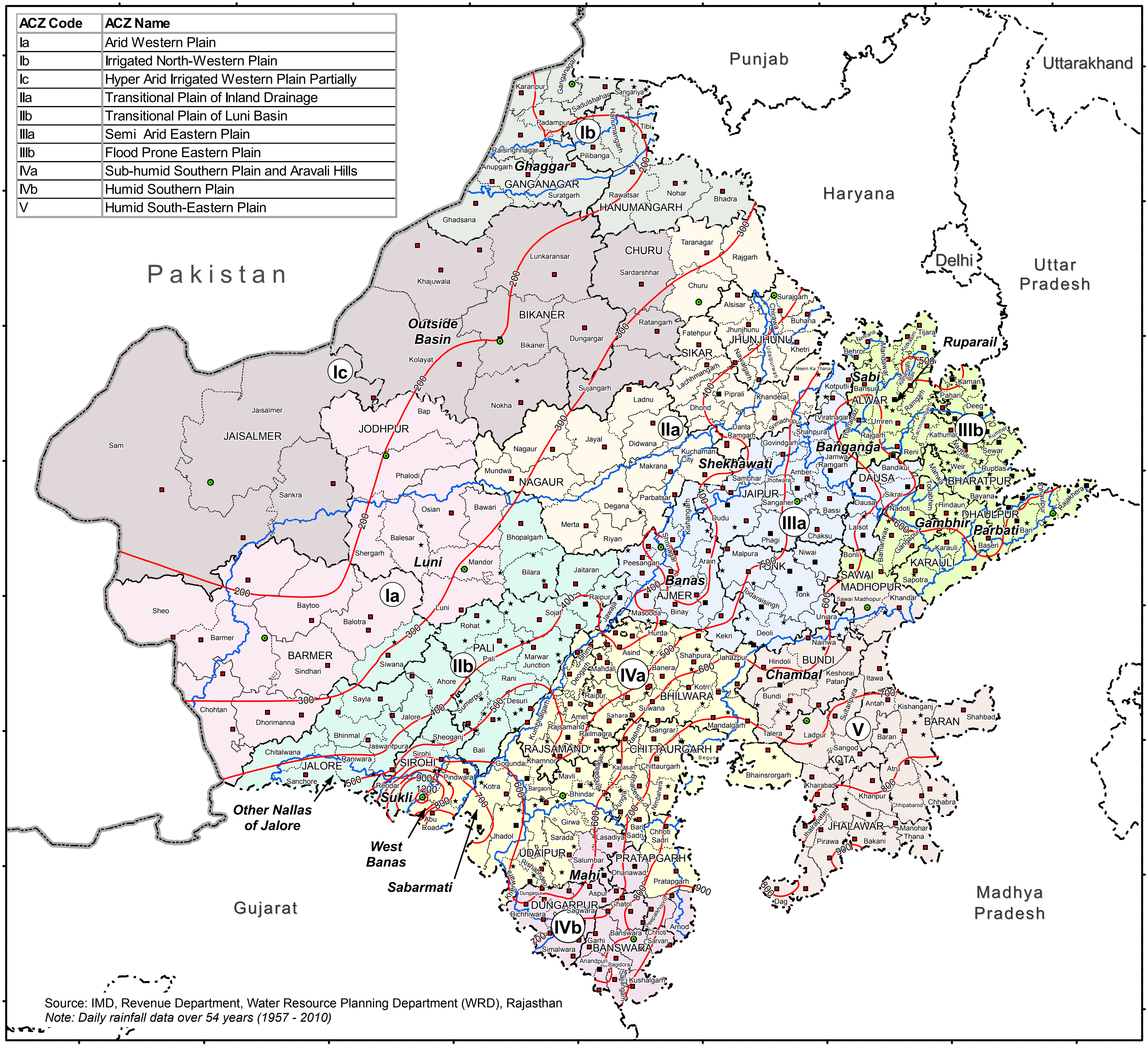
The highest mean monthly rainfall occurs in the middle months of July and August, with 198.4 and 164.0 mm respectively in each month, contributing about 67.1% of the annual rainfall, while June and September rainfalls contribute 10.5% and 14.0%, respectively. It is observed that contribution of the other three seasons to annual rainfall is marginal. Winter, pre-monsoon and the post-monsoon seasons contribute 2.2%, 3.4% and 2.8%, respectively.

Figure 7.14 shows total annual number of rainy days in Rajasthan.

---

[7] Coefficient of Variation (CV): A statistical measure of the dispersion of data points in a data series around the mean. The coefficient of variation represents the ratio of the standard deviation to the mean, and is a measure of relative dispersion used to compare variation in series which differs in magnitude of their means. The higher the CV, the greater is the dispersion in the variable.

Figure 7.12



ACZ Code	ACZ Name
Ia	Arid Western Plain
Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
IIa	Transitional Plain of Inland Drainage
IIb	Transitional Plain of Luni Basin
IIIa	Semi Arid Eastern Plain
IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: IMD, Revenue Department, Water Resource Planning Department (WRD), Rajasthan
Note: Daily rainfall data over 54 years (1957 - 2010)

MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)

- — Index Isolines (100 mm)

Boundaries

- ⋯ Block
- - - District
- ▨ Agro Climatic Zone
- ☐ River Basin
- -·- State
- ━ International

Labels

Block
Index Isoline
DISTRICT
State
River Basin
Country
ACZ

N
W
E
S

0 50 100 150 200
Km

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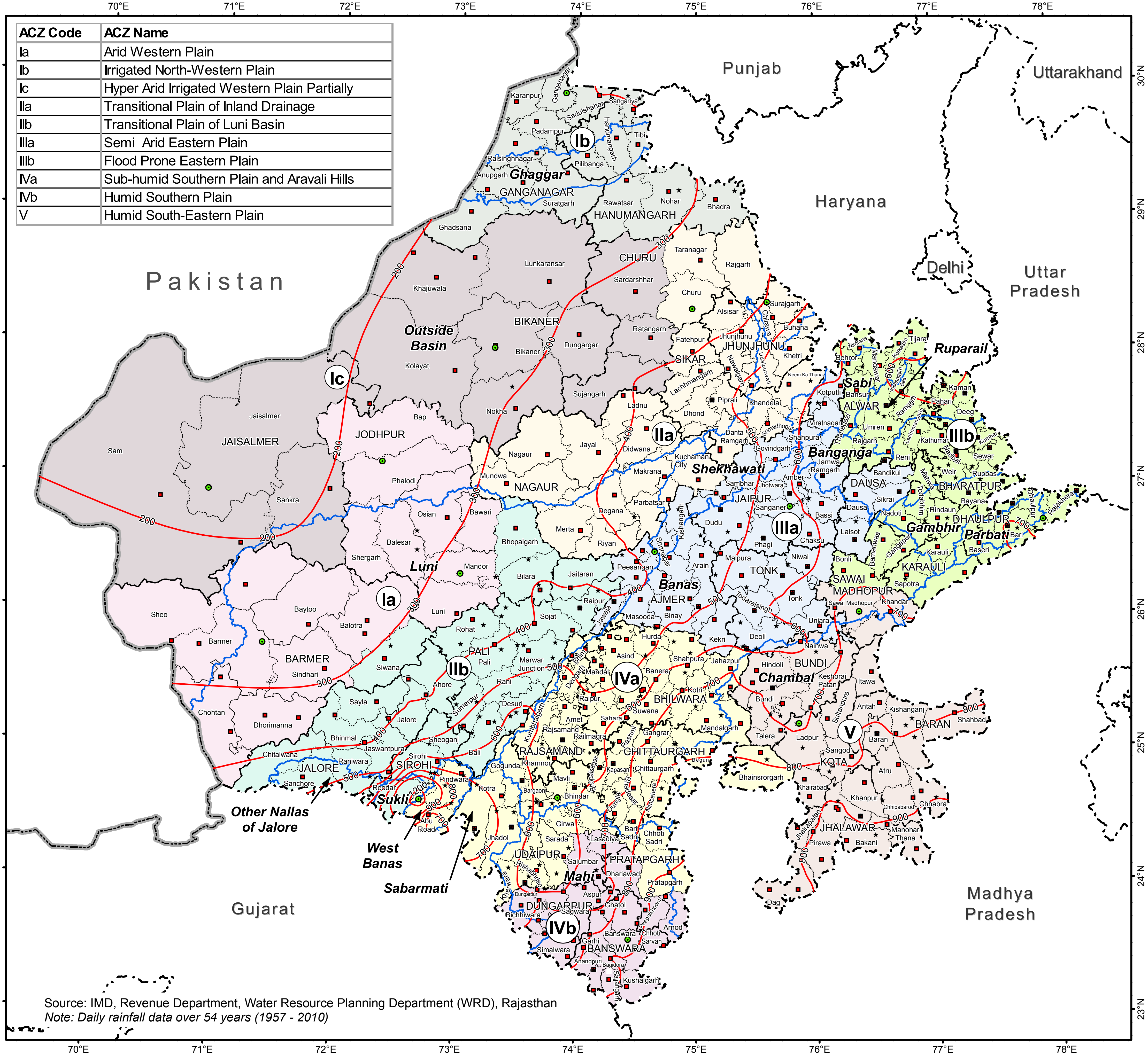
SCALE: 1:3,250,000 **DATE: August, 2012**

Figure 7.13

MEAN ANNUAL RAINFALL
RAJASTHAN



ACZ Code	ACZ Name
Ia	Arid Western Plain
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IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: IMD, Revenue Department, Water Resource Planning Department (WRD), Rajasthan

Note: Daily rainfall data over 54 years (1957 - 2010)

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)

- — Index Isoline (100 mm)

Boundaries

- ┄ Block
- - - District
- ▨ Agro Climatic Zone
- ▭ River Basin
- -·- State
- ▬ International

Labels

Block
Index Isoline
DISTRICT
River Basin
State
Country
ACZ

N
W E
S

0 50 100 150 200 Km

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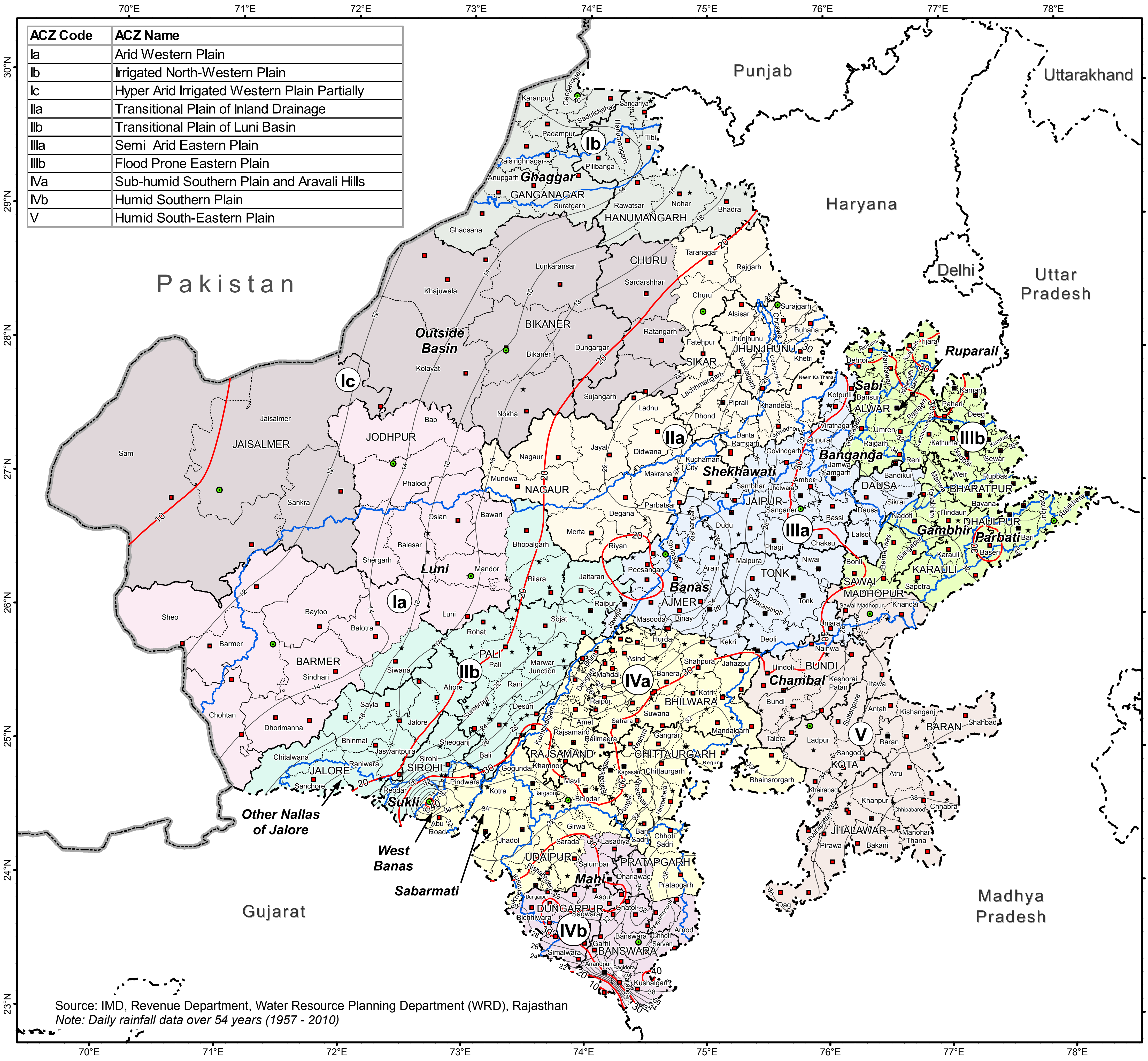
Figure 7.14



ACZ Code	ACZ Name
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IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: IMD, Revenue Department, Water Resource Planning Department (WRD), Rajasthan

Note: Daily rainfall data over 54 years (1957 - 2010)

MEAN ANNUAL RAINY DAYS

RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Number of Rainy Days

- Index Isoline (10 days)
- Intermediate Isoline (2 days)

Boundaries

- Block
- District
- Agro Climatic Zone
- River Basin
- State
- International

Labels

Block	Index Isoline
DISTRICT	Intermediate Isoline
State	*River Basin*
Country	ACZ

0 50 100 150 200 Km

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SCALE: 1:3,250,000	DATE: August, 2012

7.5 Evaporation Statistics

Evaporation in Rajasthan is highly variable, both in spatial and temporal terms. Annual evaporation ranges from 140 to over 300 cm over the State. Values exceeding 300 cm occur over western Rajasthan (observed at the IMD weather station in Jaisalmer), which mainly comprises a desert area. It is generally the highest during May (when it ranges from about 10 to 30 cm) over most parts of the State and continues to be high in June too. The minimum usually occurs in December and January, when evaporation ranges from about 3 to 15 cm per month.

Tables 7.10 and 7.11 show the total annual and mean monthly evaporation rates, respectively, obtained using data of the 20-year period of 1990 to 2009. From Table 7.10 it is evident that the total annual evaporation shows no significant trend within this 20-year period.

Table 7.10 Mean Annual Evaporation, cm

Year	Evaporation, cm
1990	222.7
1991	226.2
1992	210.4
1993	222.2
1994	205.3
1995	207.4
1996	213.6
1997	201.0
1998	215.6
1999	225.4
2000	229.0
2001	215.6
2002	255.0
2003	208.2
2004	221.5
2005	219.3
2006	203.4
2007	195.6
2008	199.1
2009	208.0
Mean	215.1
Positive(P) or Negative(N) trend	P
Confidence Level, %	70.6#

# indicates insignificant trend, as the confidence level is less than 90%.

Source: IMD Monthly Dataset from 1990 to 2009

Table 7.11 Mean Monthly Evaporation, cm

Month	Evaporation, cm
January	8.5
February	10.8
March	18.7
April	26.6
May	34.6
June	30.4
July	21.4
August	16.8
September	16.6
October	15.7
November	11.0
December	8.4
Total	219.5
Mean Monthly	18.3

Source: IMD Monthly Dataset from 1990 to 2009.

Figure 7.15 shows the mean daily evaporation per month in Rajasthan. It can be seen that the maximum monthly evaporation rate is 34.6 cm, occurring in May, while it is lowest in December (8.4 cm).

Figure 7.16 shows the total annual evaporation during years 1990 to 2009.

Figure 7.15 Mean Monthly Evaporation, cm

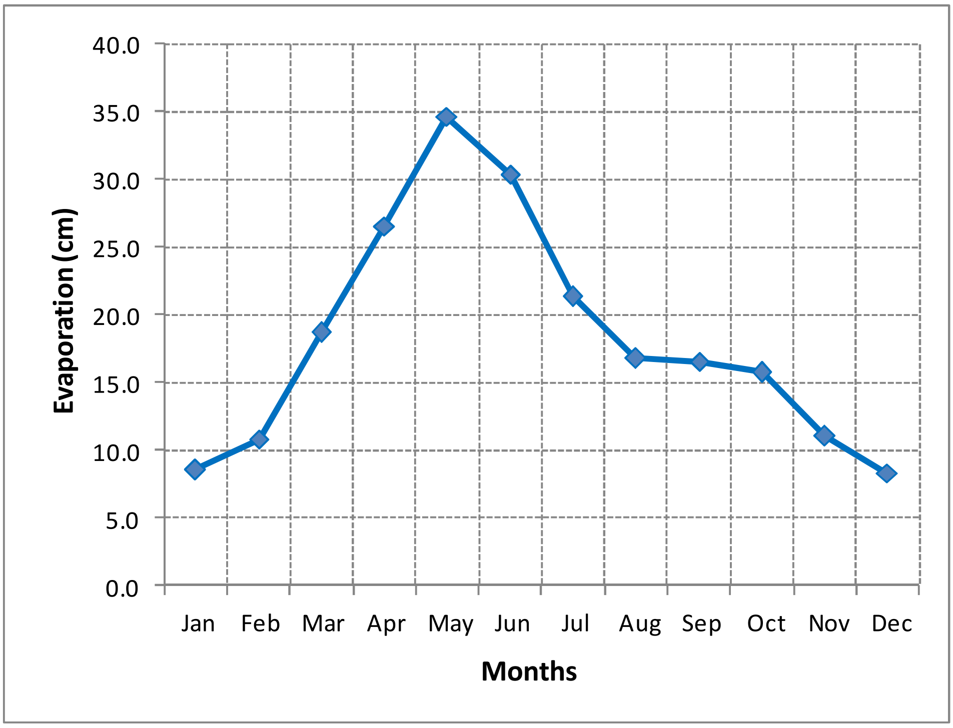
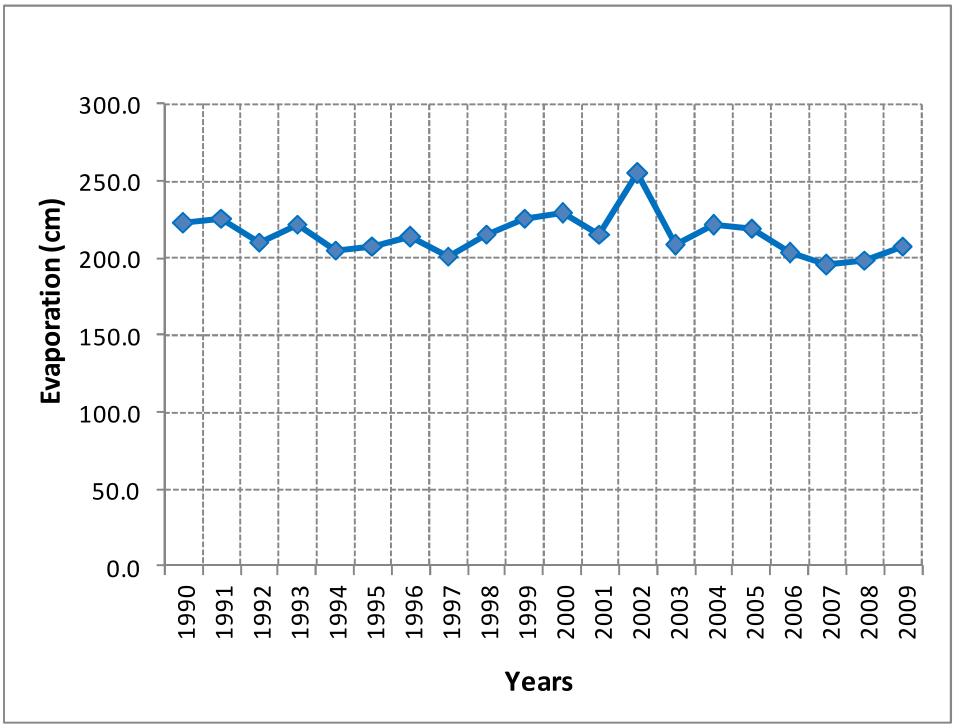


Figure 7.16 Annual Evaporation During 1990-2009, cm



7.6 Wind Speed Statistics

Tables 7.12 and 7.13 show the mean annual and mean monthly wind speeds measured during the years 1990 to 2009. It can be seen that the mean wind speed is 4.9 km/hr (or kmph), with a range of 4.1 - 6.3 km/hr.

Wind speeds show no significant trend within the study period.

Table 7.12 Mean Daily Wind Speed per Year, km/hr

Year	Wind Speed, km/hr
1990	5.7
1991	5.1
1992	5.0
1993	4.8
1994	4.6
1995	4.7
1996	4.1
1997	4.9
1998	4.4
1999	5.2
2000	5.3
2001	4.5
2002	6.0

Year	Wind Speed, km/hr
2003	5.2
2004	6.3
2005	5.1
2006	4.8
2007	4.3
2008	4.7
2009	4.5
Mean	4.9
Positive (P) or Negative (N) trend	N
Confidence Level, %	11.1#

# shows insignificant trend as the confidence level is less than 90%.

Source: IMD Monthly Dataset from 1990 to 2009

Table 7.13 Mean Monthly Wind Speed, km/hr

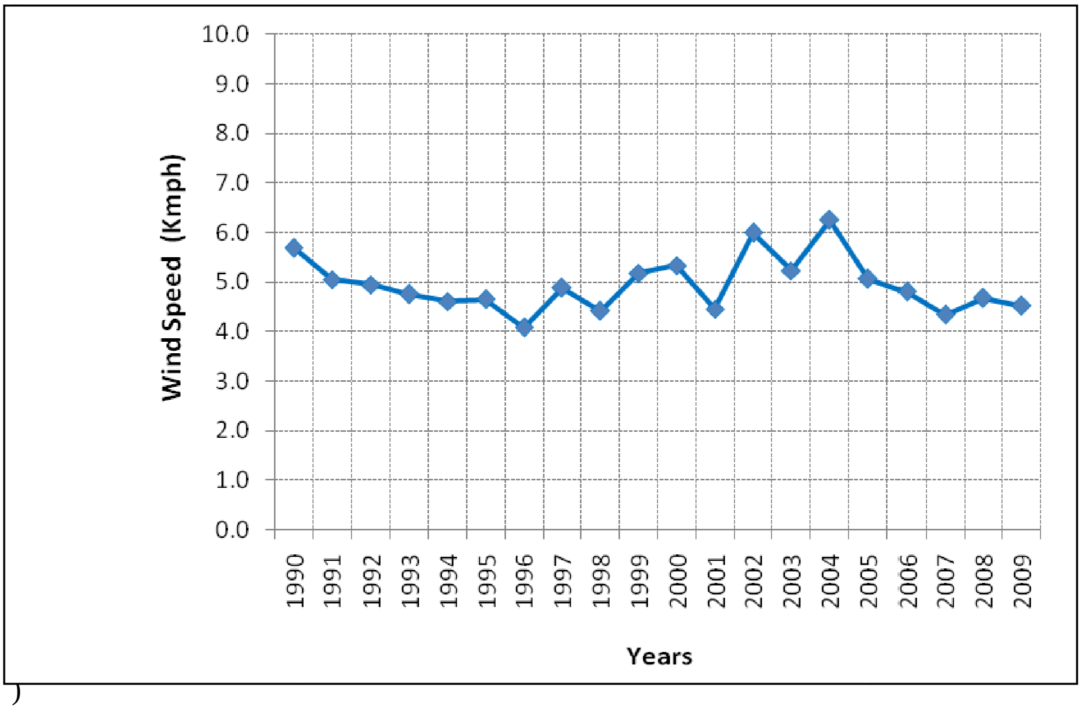
Month	Wind Speed, km/hr
Jan.	3.2
Feb.	3.9
Mar.	4.5
Apr.	5.3
May	7.4
Jun.	7.9
Jul.	7.0
Aug.	6.0
Sep.	5.0
Oct.	3.0
Nov.	2.3
Dec.	2.4

Source: IMD Monthly Dataset from 1990 to 2009

It may be observed from Table 7.13 that the wind speed in Rajasthan reaches a maximum in June.

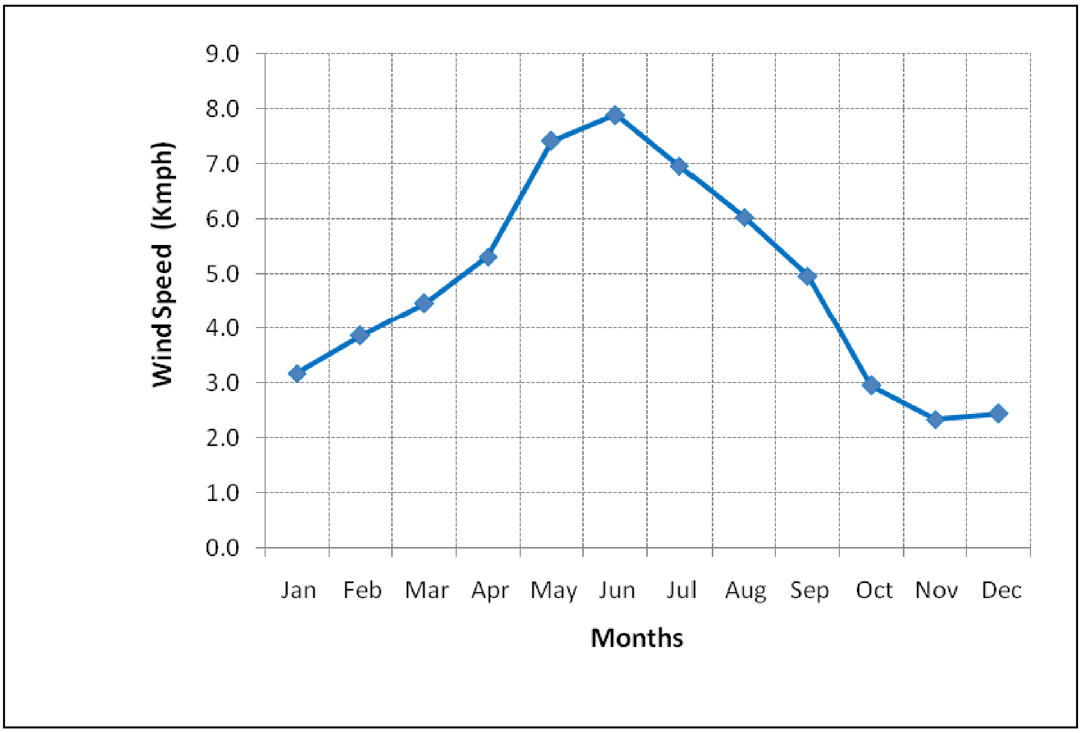
Figure 7.17 shows the variation of wind speed over the years 1990 to 2009. Figure 7.18 shows the mean monthly wind speeds

Figure. 7.17 Daily Means of Wind Speeds from 1990 to 2009, km/hr



)

Figure 7.18 Mean Daily Wind Speed per Month, km/hr



7.7 Sunshine Hours Statistics

Sunshine hours in Rajasthan range from 7.4 to 8.9 per day, as evaluated over the study period of 20 years, with a mean value of 8.1 hrs/day. Table 7.14 and Table 7.15 show mean annual and mean monthly daily sunshine hours, respectively.

Sunshine hours show no significant trend within the study period of 20 years.

Table 7.14 Mean Daily Sunshine Hours per Year in Rajasthan, Hrs

Year	Mean Number of Daily Sunshine Hours
1990	8.5
1991	8.9
1992	7.4
1993	8.1
1994	7.4
1995	7.7
1996	8.0
1997	8.3
1998	8.4
1999	8.7
2000	8.2
2001	8.1
2002	8.0
2003	7.6
2004	7.8
2005	8.2
2006	7.8
2007	8.3
2008	7.9
2009	8.3
Mean	8.1
Positive (P) or Negative (N) trend	P
Confidence Level, %	17.0#

# indicates insignificant trend as the confidence level is less than 90%.

Source: IMD Monthly Dataset from 1990 to 2009

Table 7.15 Mean Daily Sunshine Hours per Month in Rajasthan

Month	Mean Number of Daily Sunshine Hours
January	7.7
February	8.4
March	8.4
April	9.2
May	9.3
June	8.2
July	6.6
August	6.9
September	8.1
October	8.9
November	8.5
December	7.4
Mean Monthly	8.1

Source: IMD Monthly dataset (1990 - 2009)

Figure 7.19 shows the variation of the annual mean of number of sunshine hours over the years 1990 to 2009. Figure 7.20 shows the variation of the number of sunshine hours between the months in Rajasthan.

Figure 7.19 Mean Daily Sunshine Hours from 1990 to 2009

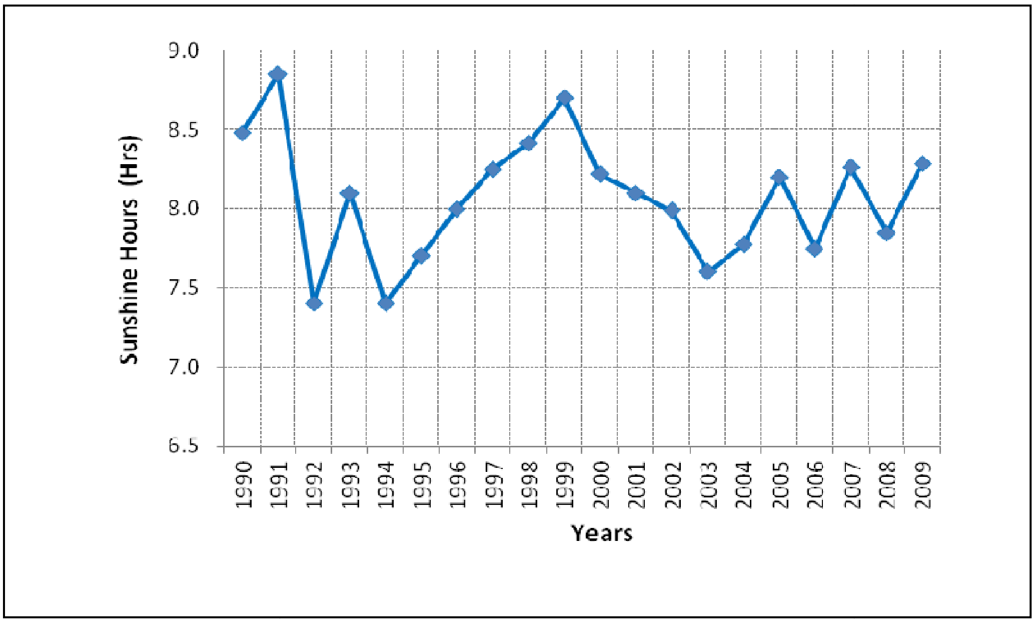
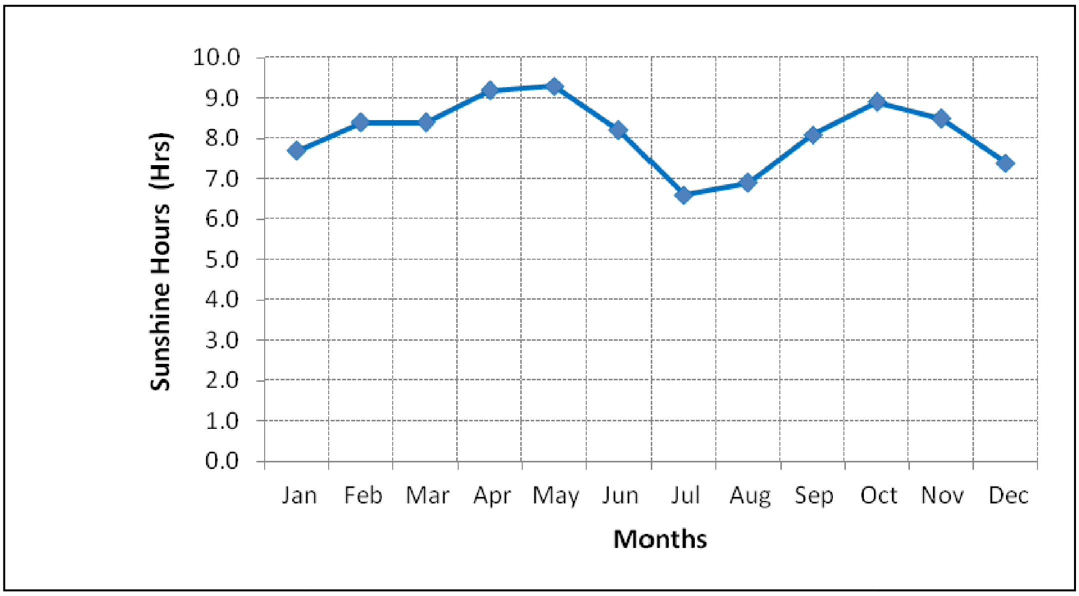


Figure 7.20 Mean Daily Sunshine Hours per Months



From Table 7.14 above it may be observed that within the study period (1990 - 2009) the number of sunshine hours was maximum in year 1991 (8.9 hrs) while it was lowest in years 1992 and 1994 (7.4 hrs).

The highest number of sunshine hours per day occurs in May, 9.2, and lowest - in July, 6.7.

7.8 Relative Humidity Statistics

Relative humidity (RH) in Rajasthan ranges from 46.8 to 57.6%, with a mean value of 50.7%.

Tables 7.16 and 7.17 show mean annual and mean monthly relative humidity in Rajasthan, respectively.

Relative humidity shows no significant trend within the study period of 20 years.

Table 7.16 Mean Daily Relative Humidity per Year, %

Year	Mean Relative Humidity, %
1990	52.1
1991	48.7
1992	51.0
1993	50.5
1994	52.0
1995	51.1
1996	52.1
1997	57.6

Year	Mean Relative Humidity, %
1998	54.3
1999	50.1
2000	47.9
2001	51.0
2002	46.8
2003	50.9
2004	49.0
2005	49.7
2006	51.3
2007	51.0
2008	50.5
2009	47.1
Mean	50.7
Positive (P) or Negative (N) trend	N
Confidence Level, %	69.0#

# indicates insignificant trend as the confidence level is less than 90%.
Source: IMD Monthly dataset (1990 - 2009)

Table 7.17 Mean Daily Relative Humidity per Month

Month	Mean Monthly Relative Humidity, %
January	54.7
February	47.9
March	38.2
April	30.5
May	35.1
June	48.4
July	67.7
August	72.6
September	64.7
October	48.4
November	48.6
December	54.6
Mean	50.9

Source: IMD Monthly dataset (1990-2009)

Figure 7.21 shows the variation in mean annual relative humidity over the years 1990 to 2009. Figure 7.22 shows the variation of mean daily relative humidity between the months.

Relative humidity is lowest in month of April (30.5%) while it is highest in month of August (72.6%).

Figure 7.21 Mean Daily Relative Humidity in % per Year, 1990 - 2009

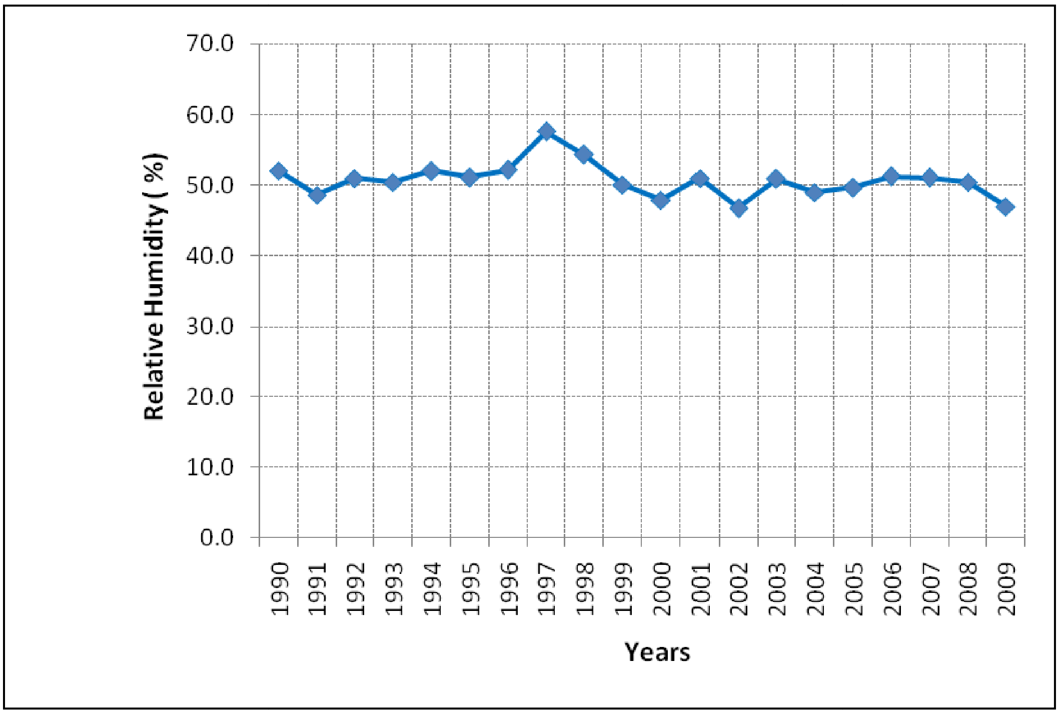
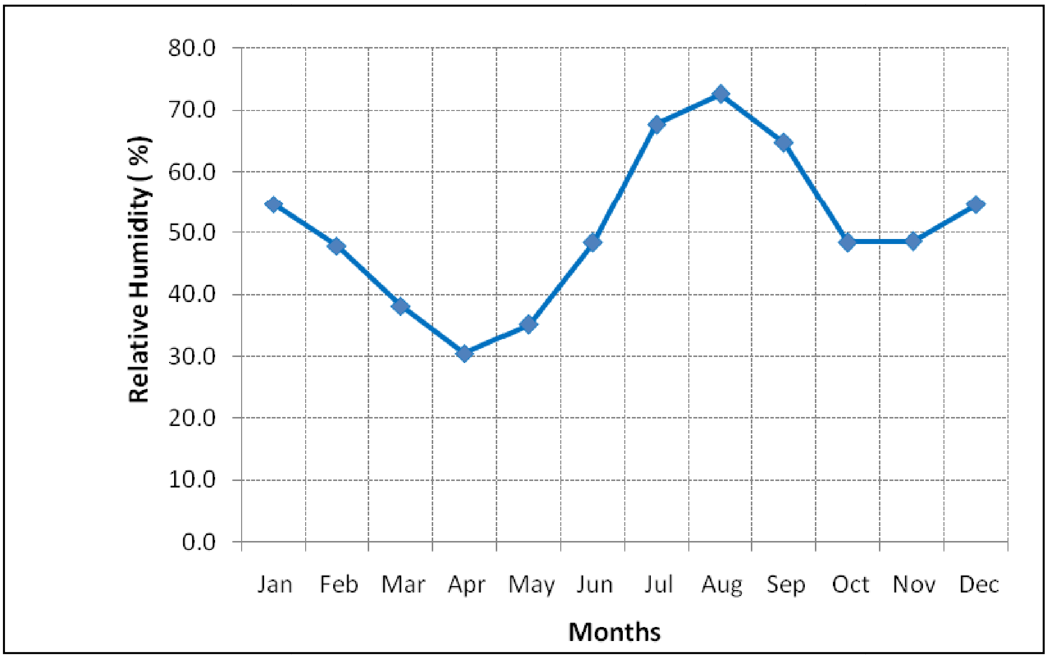


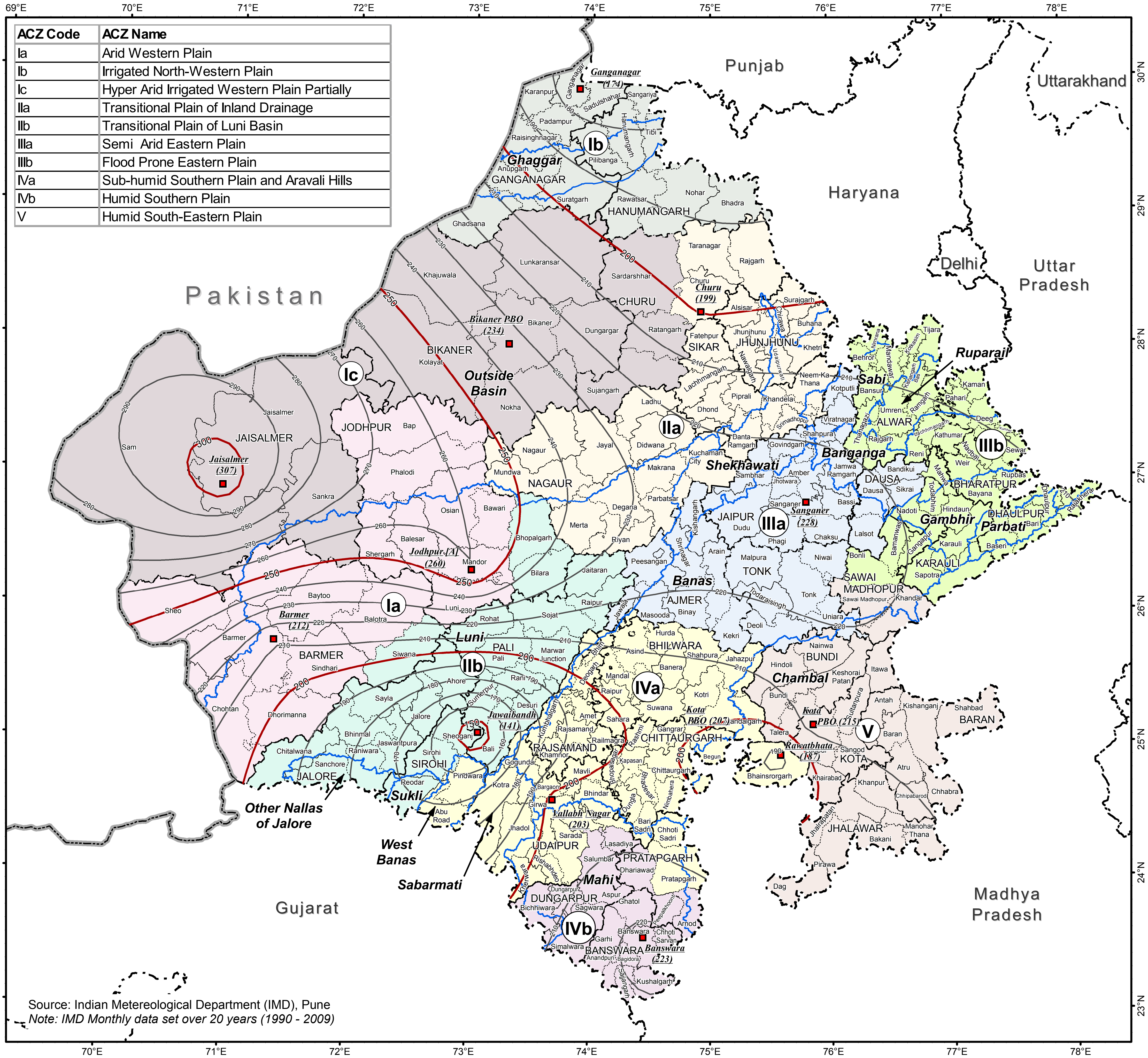
Figure 7.22 Mean Daily Relative Humidity per Month



7.9 Spatial Variation of Various Weather Parameters Across Rajasthan

Figures 7.23 to Figure 7.26 present the spatial variation of various meteorological parameters across Rajasthan.

Figure 7.23



ACZ Code	ACZ Name
Ia	Arid Western Plain
Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
IIa	Transitional Plain of Inland Drainage
IIb	Transitional Plain of Luni Basin
IIIa	Semi Arid Eastern Plain
IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL EVAPORATION
RAJASTHAN

Legend

■ Station Location

Annual Evaporation (cm)

―	Index Isoline (50 cm)
―	Intermediate Isoline (10 cm)

Boundaries

⬚	Block
⬚	District
▨	Agro Climatic Zone
▭	River Basin
⬚	State
⬚	International

Labels

Block
DISTRICT
State
Country
Station Name (Mean Value)
Index Isoline
Intermediate Isoline
River Basin
ACZ

N
W E
S

0 50 100 150 200 Km

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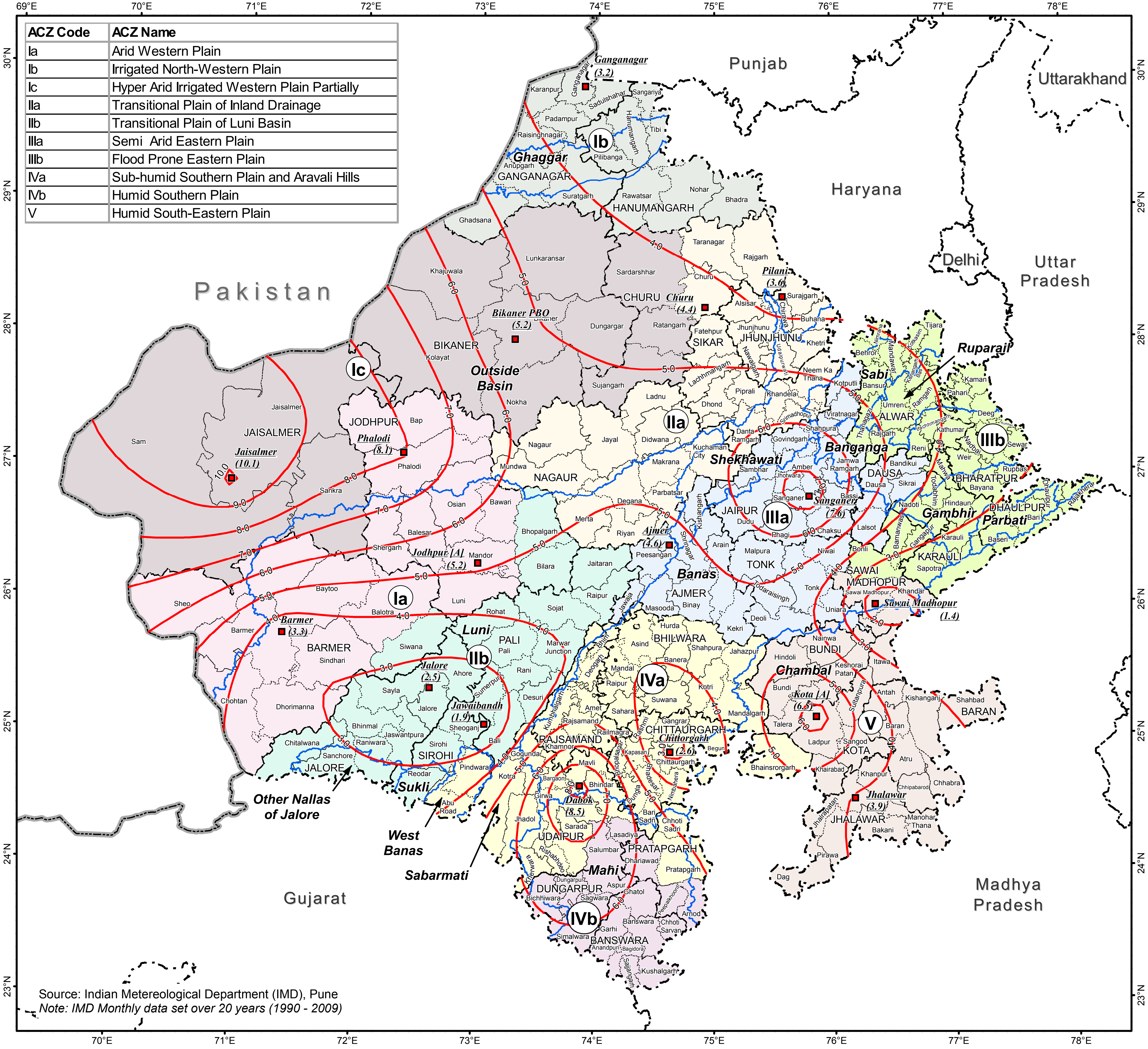
Figure 7.24



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IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED
RAJASTHAN

Legend

■	Station Location

Windspeed (km/h)

—	Index Isoline (1 km/h)

Boundaries

┈	Block
╌	District
▨	Agro Climatic Zone
▭	River Basin
╌·	State
━	International

Labels

Block	*Station Name (Mean Value)*
DISTRICT	Index Isoline
State	*River Basin*
Country	ACZ

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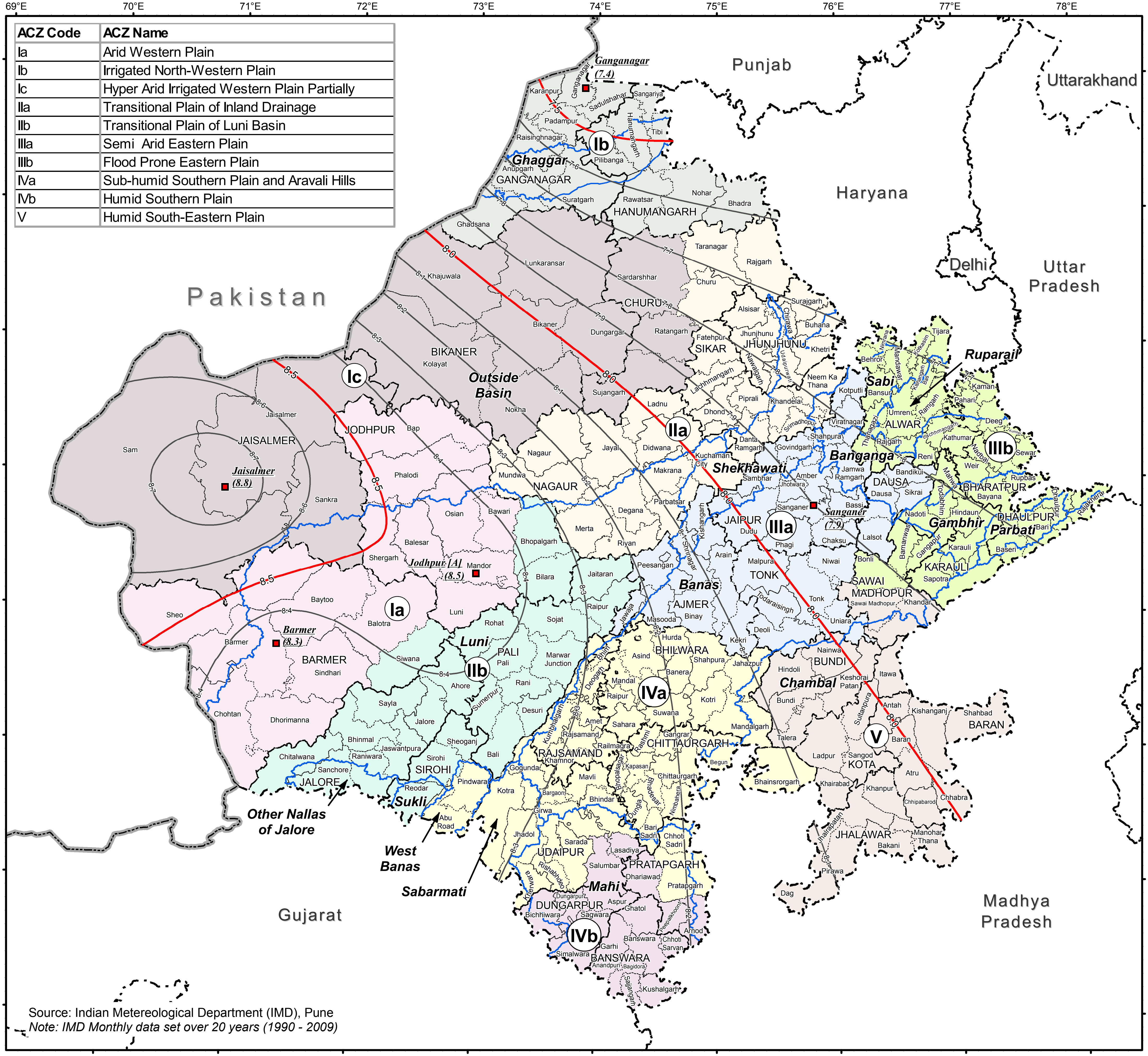
Figure 7.25



ACZ Code	ACZ Name
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IIIb	Flood Prone Eastern Plain
IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY SUNSHINE HOURS

RAJASTHAN

Legend

■ Station Location

Sunshine Hours

Index Isoline (30 minute)

Intermediate Isoline (6 minute)

Boundaries

Block

District

Agro Climatic Zone

River Basin

State

International

Labels

Block	*Station Name (Mean Value)*
DISTRICT	Index Isoline
	Intermediate Isoline
State	***River Basin***
Country	ACZ

N
W E
S

0 50 100 150 200 Km

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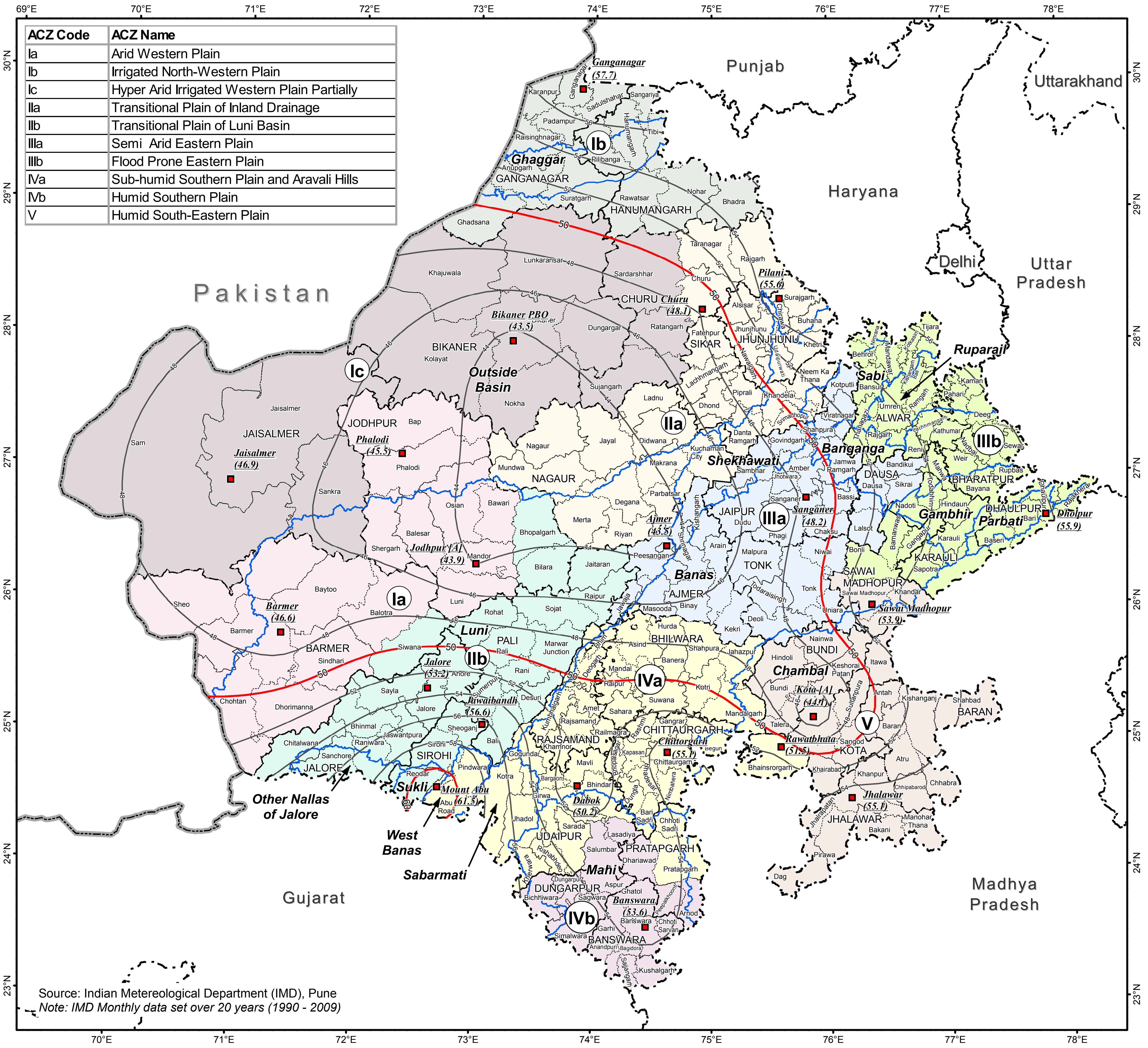
Figure 7.26



ACZ Code	ACZ Name
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Ib	Irrigated North-Western Plain
Ic	Hyper Arid Irrigated Western Plain Partially
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IVa	Sub-humid Southern Plain and Aravali Hills
IVb	Humid Southern Plain
V	Humid South-Eastern Plain

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY RELATIVE HUMIDITY
RAJASTHAN

Legend

■ Station Location

Relative Humidity (%)

—	Index Isoline (10%)
—	Intermediate Isoline (2%)

Boundaries

┈	Block
╌	District
▨	Agro Climatic Zone
▭	River Basin
─·─	State
─··─	International

Labels

Block
DISTRICT
State
Country
Station Name (Mean Value)
Index Isoline
Intermediate Isoline
River Basin
ACZ

N
W E
S

0 50 100 150 200 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:3,250,000
DATE: August, 2012

7.10 Analysis of Observed Climatology in the Various Agroclimatic Zones

7.10.1 Temperature

ACZ-wise maximum and minimum temperature statistics have been evaluated, along with trend analysis over the study period, and are presented in the respective sub-paragraphs below.

a) Maximum Temperature

Table 7.18 shows maximum temperature statistics in the various ACZs. It is evident from this table that the mean maximum temperature is highest in the Arid Western Zone, with 34.2°C, and lowest in the Sub-Humid Southern Plain, with 32.3°C.

Table 7.18 Agroclimatic Zone-Wise Mean Annual Daily Maximum Temperature Statistics, °C

Agroclimatic Zone		Min.	Max.	Variation	Mean	CV*
Ia	Arid Western	32.80	35.00	2.20	34.20	0.01
Ib	Irrigated North Western Plain	33.10	34.10	1.00	33.50	0.01
Ic	Hyper Arid Irrigated Western Plain Partially	33.60	34.70	1.10	34.10	0.01
IIa	Transitional Plain of inland drainage	32.60	34.30	1.70	33.40	0.01
IIb	Transitional Plain of Luni Basin	25.90	34.60	8.70	32.80	0.04
IIIa	Semi-Arid Eastern Plain	32.40	33.20	0.80	32.80	0.00
IIIb	Flood Prone Eastern Plain	32.70	33.90	1.20	33.20	0.01
IVa	Sub-humid Southern Plain	25.90	33.20	7.30	32.30	0.03
IVb	Humid southern Plain	31.80	33.60	1.80	33.00	0.01
V	Humid South-Eastern Plain	31.80	33.20	1.40	32.60	0.01

* CV - Coefficient of Variation

From Table 7.19 below it is evident that zones IIa, IIb, IIIa, IIIb and IVa, show significant increasing trends in maximum temperature (confidence level >90%) while IIIb shows a significant decreasing trend. The rest of the zones show statistically insignificant trends.

In ACZ IIa, IIb, IIIa and IVa, the mean maximum temperature has increased by 1.87, 1.67, 1.09 and 2.03°C, respectively, while in ACZ IIIb the temperature has decreased by 2.46°C within a span of 20 years (1990 - 2009).

Mean monthly statistics show that the maximum temperature is highest in May and lowest in January.

It is also evident from Table 7.19 that within the study period (1990-2009) Minimum and Maximum of Highest Maximum temperature both has occurred in ACZ IIIb with values 38.8°C (Year 2009) and 50.0°C (Year 1995) respectively.

Among all the Agro Climatic Zones Ia, Ic, IIIb, IVb and Zone V shows significant trend (all Decreasing) while rest of the ACZ shows insignificant trend for Highest Maximum temperature.

Table 7.19 Agroclimatic-Zone-Wise Trend and Mean Annual Daily and Monthly Maximum Temperature alongwith Highest Maximum temperature, °C

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Mean Annual Daily Maximum Temperature										
1990	34.1	32.5	34.4	33.3	33.0	31.8	33.3	29.3	33.5	32.3
1991	34.8	32.5	34.2	32.6	33.8	32.3	34.3	30.5	33.6	33.5
1992	34.2	32.0	33.4	32.1	33.3	31.5	35.3	30.0	34.0	32.8
1993	35.3	33.4	35.0	32.9	34.1	32.7	35.3	30.9	34.0	33.1
1994	34.3	32.5	34.2	32.4	33.1	32.3	35.0	30.0	32.9	32.7
1995	34.7	NA*	34.3	32.4	33.3	32.2	34.8	30.3	35.4	32.9
1996	34.4	NA	34.3	31.9	34.0	32.4	33.8	30.7	33.2	33.0
1997	33.1	30.7	32.7	31.1	32.9	30.4	32.1	29.0	31.0	30.5
1998	35.2	32.6	34.4	33.1	34.8	32.5	34.1	30.5	33.0	30.7
1999	35.3	33.7	34.7	34.1	34.1	33.3	34.5	30.7	33.2	31.0
2000	35.3	33.6	35.2	34.0	33.7	33.3	33.8	31.3	34.9	32.0
2001	34.9	33.5	34.5	33.5	32.4	32.9	NA	28.9	34.2	31.6
2002	35.8	34.4	35.4	34.9	33.6	33.9	34.3	31.7	34.2	35.1
2003	33.1	32.8	33.6	32.4	34.3	32.4	32.6	29.4	33.1	32.9
2004	35.6	34.6	35.7	36.1	35.1	33.1	33.6	31.3	34.0	34.3
2005	34.1	33.2	33.7	33.0	34.5	32.8	32.9	31.3	33.3	32.5
2006	34.9	33.8	34.1	33.7	34.9	33.0	33.9	31.3	33.3	32.8
2007	34.6	31.9	34.2	33.3	34.5	32.7	33.1	31.4	34.1	33.2
2008	33.9	33.4	34.4	32.8	34.1	32.7	33.5	30.1	34.4	33.2
2009	35.8	34.0	34.5	34.5	35.5	33.2	NA	32.5	33.6	34.2
Positive (P) or Negative (N) trend	P	P	P	P	P	P	N	P	P	P
Confidence Level, %	69.0#	86.0#	60.0#	98.0	99.0	97.0	99.0	99.0	60.0#	56.0#
Change in Temperature, °C (1990 - 2009)	0.7	1.2	0.4	1.9	1.7	1.1	-2.5	2.0	0.5	1.3
Monthly										
January	25.3	20.3	23.6	22.4	26.7	23.6	22.8	23.4	27.6	24.0
February	28.6	23.8	27.0	25.7	29.5	26.6	27.6	26.6	30.3	27.6
March	34.1	29.9	32.8	32.0	34.4	32.1	34.1	31.7	35.5	33.6
April	39.2	37.2	38.7	38.4	38.6	37.6	40.3	36.2	39.5	39.1
May	41.9	41.8	42.0	41.6	40.7	40.5	43.4	38.6	40.5	42.5
June	40.8	41.6	41.3	40.6	39.0	39.0	42.0	36.3	37.8	40.1
July	37.2	38.7	38.5	37.2	34.4	34.3	36.4	30.7	32.0	33.9
August	35.3	38.2	37.0	36.2	32.8	32.5	34.1	29.1	30.4	31.7
September	36.6	37.1	37.3	36.4	34.5	34.0	34.7	30.8	32.6	33.5

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
October	36.7	35.0	36.2	35.1	35.7	34.2	35.1	31.9	34.7	34.2
November	32.2	29.7	31.3	30.4	32.1	30.1	30.7	28.4	32.3	30.1
December	27.4	23.5	25.8	24.8	28.2	25.7	24.8	24.9	29.1	25.4
Mean Monthly	34.6	33.1	34.3	33.4	33.9	32.5	33.8	30.7	33.5	33.0
Highest Maximum Temperature										
1990	45.5	46.6	45.5	45.2	44.8	42.5	46.1	39.9	45.3	44.7
1991	48.4	46.3	48.3	44.0	45.0	44.5	46.2	43.4	47.5	46.0
1992	47.5	47.9	48.3	45.6	44.4	45.0	49.0	42.6	45.8	46.6
1993	46.4	48.0	47.9	46.8	43.8	44.5	48.7	42.2	45.2	47.7
1994	48.3	48.3	47.5	46.4	44.5	47.3	49.8	44.0	46.0	48.2
1995	48.1	NA	47.0	46.8	45.5	45.5	50.0	43.7	46.2	48.0
1996	45.6	NA	46.9	45.7	43.9	43.8	48.0	42.2	45.0	47.2
1997	45.1	44.8	44.5	44.2	42.5	42.1	45.0	40.3	41.5	44.5
1998	48.4	47.9	47.9	48.4	47.5	45.8	49.8	43.1	46.4	47.7
1999	45.6	46.6	45.5	47.4	44.6	44.4	48.4	42.9	43.0	45.9
2000	45.8	46.6	46.0	45.8	44.2	43.6	NA	40.6	45.4	46.1
2001	46.9	48.5	47.0	46.9	43.5	44.4	NA	39.4	45.0	46.8
2002	48.0	47.3	46.7	47.0	42.2	44.7	47.5	42.6	46.4	46.6
2003	44.9	47.8	45.5	47.6	45.0	44.5	48.3	40.7	44.4	46.9
2004	45.9	47.0	45.4	46.2	45.5	43.8	46.8	42.3	45.0	46.7
2005	44.9	47.6	45.1	46.3	45.0	44.2	46.2	42.7	44.4	46.0
2006	46.9	47.9	47.0	46.2	45.9	44.3	46.6	43.2	45.0	44.4
2007	45.1	42.2	45.3	46.7	43.8	44.3	46.7	42.6	44.7	45.6
2008	44.1	45.2	44.3	44.8	43.3	43.2	45.5	40.2	43.4	44.5
2009	46.4	47.7	47.6	48.5	44.9	44.7	38.8	44.5	44.5	46.5
Mean Annual	46.4	46.9	46.4	46.3	44.5	44.3	47.1	42.1	45.0	46.3
Trend	N	N	N	P	N	N	N	P	N	N
Confidence level,%	93.0	61.0#	100.0	87.0#	10.0#	57.0#	96.0	3.0#	98.0	91.0

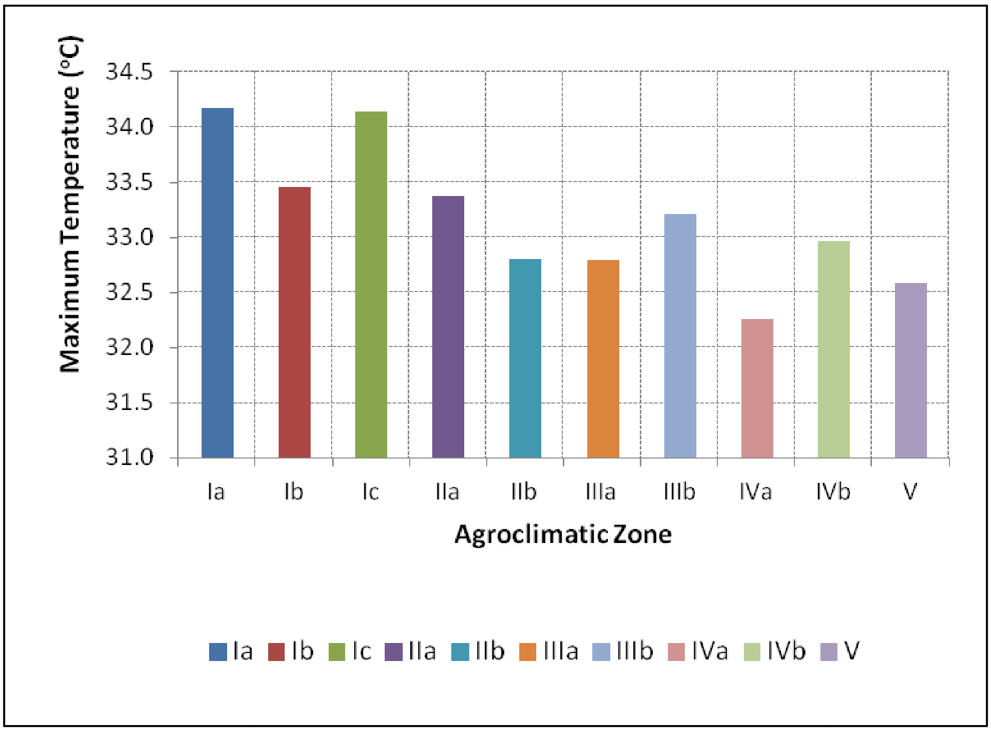
Source: IMD monthly dataset (1990-2009)

# shows an insignificant trend as the confidence level is less than 90%.

* NA : Data Not Available

Figure 7.27 shows ACZ-wise mean annual daily maximum temperature as evaluated by interpolation using available IMD stations data.

Figure 7.27 Agroclimatic Zone-Wise Mean Annual Maximum Temperature, °C



b) Minimum Temperature

Tables 7.20 and Table 7.21 show ACZ-wise minimum temperature statistics and trends, and mean monthly minimum temperatures, respectively.

It can be seen from Table 7.20 that the mean minimum temperature is highest in the Humid South-Eastern Plain (ACZ V) with a value of 19.9°C, and lowest in the Sub Humid Southern Plain (ACZ IVa) with a value of 18.2°C.

Table 7.20 Agroclimatic Zone-Wise Mean Annual Daily Minimum Temperature Statistics, °C

Agroclimatic Zone		Min.	Max.	Variation	Mean	CV*
Ia	Arid Western	18.30	20.90	2.60	19.50	0.03
Ib	Irrigated North Western Plain	18.10	19.40	1.30	18.50	0.02
Ic	Hyper Arid Irrigated Western Plain Partially	18.20	20.40	2.20	19.50	0.02
IIa	Transitional Plain of inland drainage	17.30	20.60	3.30	18.90	0.04
IIb	Transitional Plain of Luni Basin	12.00	20.30	8.30	18.40	0.07
IIIa	Semi-Arid Eastern Plain	18.40	20.70	2.30	19.60	0.02
IIIb	Flood Prone Eastern Plain	18.20	19.40	1.10	19.20	0.01
IVa	Sub humid Southern Plain	12.00	20.20	8.20	18.20	0.07
IVb	Humid Southern Plain	17.80	20.80	3.00	19.60	0.04
V	Humid South-Eastern Plain	19.10	21.90	2.80	19.90	0.03

* CV - Coefficient of Variation

From Table 7.21 it can be observed that the minimum temperature attains its highest value during June in most of the zones while the lowest temperature occurs in January.

ACZs Ib, Ic, IVa and V show statistically increasing trends, with greater than 90% confidence level. The rest of the zones show statistically insignificant trends.

In ACZs Ib, Ic, IVa and V, the mean minimum temperature has increased by 0.84, 1.48, 1.83 and 1.68°C, respectively, within a span of 20 years (1990 - 2009).

Table 7.21 Agroclimatic Zone-Wise Trend and Mean Annual Daily and Monthly Minimum Temperature, °C

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Mean Annual Daily Minimum Temperature										
1990	19.9	18.2	19.9	17.4	19.4	19.8	NA	15.9	18.2	18.2
1991	19.2	17.7	19.7	17.3	19.6	19.8	22.6	15.9	20.2	20.8
1992	19.2	17.7	19.5	17.9	18.0	19.2	20.8	14.9	20.6	20.3
1993	19.4	17.5	20.1	17.9	17.9	20.2	20.0	16.1	21.4	19.9
1994	19.1	17.2	19.8	17.8	16.0	19.9	19.5	15.3	20.3	18.7
1995	19.3	NA	20.0	16.8	18.6	20.4	19.5	17.0	22.2	19.3
1996	18.6	NA	19.0	14.7	18.8	20.1	16.5	17.2	20.8	19.4
1997	19.5	16.7	19.4	16.9	19.5	18.9	17.6	16.5	19.9	20.0
1998	20.4	18.1	20.8	18.1	20.2	19.9	19.6	16.9	19.4	19.6
1999	20.2	18.2	20.5	18.0	19.0	19.9	18.5	16.3	17.6	19.0
2000	19.8	18.4	20.4	17.8	18.6	20.2	15.2	16.2	19.4	21.1
2001	19.9	18.1	19.9	17.5	18.8	19.8	NA	15.2	21.0	19.8
2002	19.6	18.8	20.2	18.5	19.2	21.0	22.5	16.9	21.4	22.3
2003	18.7	17.9	19.0	16.3	19.6	19.8	17.1	15.2	20.9	20.5
2004	21.0	19.9	21.7	20.3	16.4	21.1	21.3	16.7	22.2	21.5
2005	18.9	18.1	20.1	16.9	17.0	20.2	19.6	16.9	21.1	19.4
2006	19.3	19.2	21.1	18.9	19.6	20.3	20.1	17.2	21.7	20.1
2007	19.8	18.0	20.8	18.1	19.8	19.5	17.6	17.8	22.7	21.2
2008	19.0	18.2	21.0	16.9	18.5	20.0	20.1	16.5	23.0	20.8
2009	22.1	18.2	20.7	18.5	20.1	20.6	NA	18.3	21.8	21.4
Positive (P) or Negative (N) trend	P	P	P	P	P	P	N	P	P	P
Confidence Level, %	54.0$^{\#}$	93.0	100.0	77.0$^{\#}$	74.0$^{\#}$	88.0$^{\#}$	41.0$^{\#}$	97.0	67.0$^{\#}$	97.0
Change in Temperature, °C (1990-2009)	0.6	0.8	1.5	0.8	1.7	0.6	-1.7	1.8	1.9	1.7
Monthly										
ACZ Month	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
January	8.9	6.1	8.6	5.5	8.3	9.4	7.6	6.9	12.7	9.6
February	11.9	8.9	12.1	9.2	10.9	12.6	11.1	9.6	14.7	12.5
March	17.4	13.4	17.5	14.3	16.6	17.9	16.3	14.8	19.1	18.1
April	22.7	19.1	23.1	20.1	21.8	23.4	22.6	19.7	23.3	23.5
May	26.5	25.1	27.0	25.7	25.9	27.4	27.1	24.1	26.4	28.1

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
June	27.5	27.8	28.4	27.5	26.2	27.7	28.4	24.3	26.5	28.1
July	26.5	28.3	27.7	27.1	24.9	26.0	26.8	22.7	24.7	25.7
August	25.4	27.6	26.6	26.0	23.8	24.8	25.4	21.6	23.9	24.6
September	24.3	24.2	25.4	23.7	23.3	24.1	24.2	20.5	23.4	24.0
October	20.3	18.0	21.1	17.8	19.2	20.5	19.3	16.4	20.8	20.0
November	14.6	11.5	15.1	11.2	13.3	15.1	13.4	11.4	17.0	15.1
December	10.2	7.1	10.0	6.4	9.0	10.6	9.0	7.7	13.8	10.7
Mean Monthly	19.7	18.1	20.2	17.9	18.6	20.0	19.3	16.6	20.5	20.0
Lowest Minimum Temperature										
1990	1.5	1.9	1.2	0.2	1.4	3.5	-4.3	-0.3	4.5	5.3
1991	1.6	0.7	1.5	0.2	0.8	2.5	5.0	-0.6	4.8	3.4
1992	4.1	1.7	3.1	3.0	1.4	3.8	5.4	0.7	8.5	4.8
1993	4.8	1.2	3.7	1.8	3.3	5.7	4.7	2.3	10.1	6.0
1994	2.7	0.6	2.8	0.9	0.6	4.6	5.1	-0.2	10.2	4.4
1995	3.7	NA	3.3	1.4	0.3	4.5	4.0	3.3	12.0	5.0
1996	3.6	NA	1.6	-2.2	2.4	6.3	4.0	2.3	8.5	4.5
1997	3.8	1.5	3.9	-0.6	4.3	4.8	3.5	2.0	6.8	5.0
1998	4.3	1.5	4.5	0.2	3.5	4.6	3.7	1.1	7.5	4.3
1999	5.7	2.3	4.3	-0.2	2.9	5.4	2.3	2.2	5.8	5.6
2000	3.2	1.3	2.1	-1.5	-3.1	4.3	NA	-0.3	5.0	6.3
2001	4.1	0.2	3.2	0.2	3.5	4.5	NA	-1.0	8.9	5.5
2002	3.0	1.6	3.6	-0.7	2.6	5.4	6.9	2.3	8.9	7.6
2003	3.6	1.0	3.1	-0.4	4.3	5.7	0.8	0.1	8.2	5.5
2004	4.9	3.2	4.8	2.2	1.0	5.0	3.7	2.9	10.5	6.2
2005	3.1	1.2	3.7	-0.1	3.0	4.2	5.5	1.5	7.2	5.2
2006	2.2	-0.8	2.4	-2.8	4.0	4.6	4.0	3.6	9.5	6.1
2007	3.4	0.7	4.1	-0.2	5.0	4.3	4.0	3.0	11.0	6.1
2008	2.3	-0.5	1.8	-1.3	2.5	3.7	4.3	-0.1	6.5	4.4
2009	7.6	2.7	5.5	2.0	3.6	7.6	4.5	5.8	12.5	7.2
Mean Annual	3.6	1.2	3.2	0.1	2.4	4.7	3.7	1.5	8.3	5.4
Trend	P	N	P	N	P	P	N	P	P	P
Confidence level,%	33.0#	57.0#	94.0	86.0#	96.0	33.0#	0.0#	93.0	52.0#	97.0

Source : IMD Monthly dataset (1990-2009)

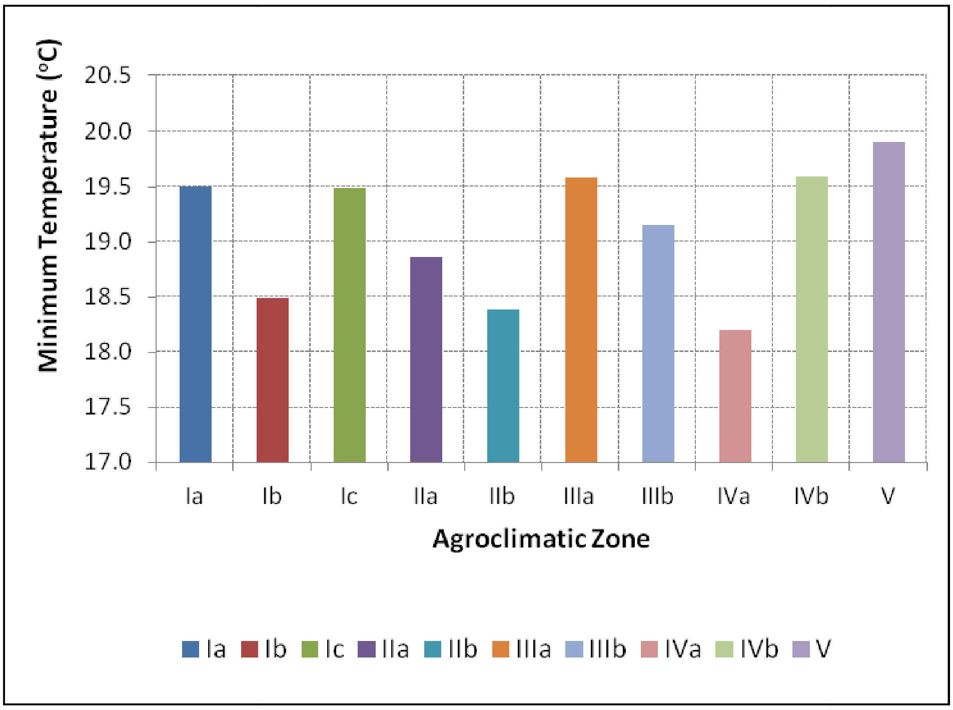
# shows insignificant trend, as the confidence level is less than 90%.

Within the study period (1990-2009) range for Lowest minimum temperatures were -4.3°C (Year 1990) and 12.5°C (Year 2009), respectively.

In lowest minimum temperatures ACZ Ic, IIb, IVa and V shows significant trend (all increasing) while rest of the zones shows insignificant trend.

Figure 7.28 shows ACZ-wise mean annual daily minimum temperature as evaluated by interpolation using available IMD stations data.

Figure 7.28 Agroclimatic Zone-Wise Mean Annual Daily Minimum Temperature, °C



7.10.2 Agroclimatic Zone-Wise Rainfall Data Statistics

After all the scrutinizing, 327 raingauge stations could qualify to be considered for further analysis, including those stations that required infilling of missing records (days in present case, as filling is performed on daily rainfall data).

ACZ-wise details of filling of missing rainfall data in monsoon months are summarized in Table 7.22.

Table 7.22 Agroclimatic Zone-Wise Details of Monsoon Months Filled Data (Daily Records, days)

ACZ	Area, km^2	Filled Records, days	Total Number of records, days	% Filling,	No. of Stations	Stations per 1,000 km^2 area
Ia	45,578	1,797	60,720	3	10	0.22
Ib	20,621	5,389	113,640	5	18	0.87
Ic	77,002	1,448	56,040	3	9	0.12
IIa	37,055	1,251	113,280	1	18	0.49
IIb	31,657	10,733	188,520	6	30	0.95
IIIa	29,513	7,037	306,000	2	50	1.69
IIIb	24,432	7,254	344,400	2	55	2.25
IVa	37,563	11,533	451,080	3	73	1.94
IVb	11,979	1,500	180,120	1	29	2.42
V	26,864	4,513	215,880	2	35	1.30

Table 7.22 presents a summary of the percentage of total infilled values of the monsoon months (JJAS) records, considering all the stations falling in each zone. It is evident

that ACZ IIb has the maximum number of records being filled, 6%, while the minimum number of fillings, 1%, occurs in ACZ IIa and IVb.

This table also shows the number of usable stations available per 1000 km^2. The highest density occurs in ACZ IVb, with 2.42 stations per 1000 km^2, while the lowest is in ACZ Ic, with only 0.12 stations per 1000 km^2.

Figure 7.29 is a graphical plot of the number of stations per ACZ, and the respective filling percentage.

Figures 7.30 to Figure 7.39 show percentage of monsoon months records filled in various rain-gauge stations in the different ACZs. The percentage infilling of data in individual stations ranges from 0 to 18% with a maximum of 18% of infilling being in Jograwas raingauge station (WRIS code 365) in Pali District, falling under ACZ IIb.

Figure 7.40 shows the ratio of raingauge station's infilled records to the total number of records, expressed as percentage.

Figure 7.41 shows, as an example, the annual rainfall data of Kota Barrage rain gauge station before and after filling of missing data, wherein the amount of rainfall filled is also shown.

Detailed Summary of rain gauge stations are presented in Appendix 7 (Volume 2 of this report), while number of Excess, Normal, Deficient, Scanty and No rain Years at various rain gauge stations are presented in Appendix 8 (Volume 2 of this report).

Figure 7.29 Graphical Plot of Agroclimatic Zone-Wise Number of Stations and Extent of Data Filling

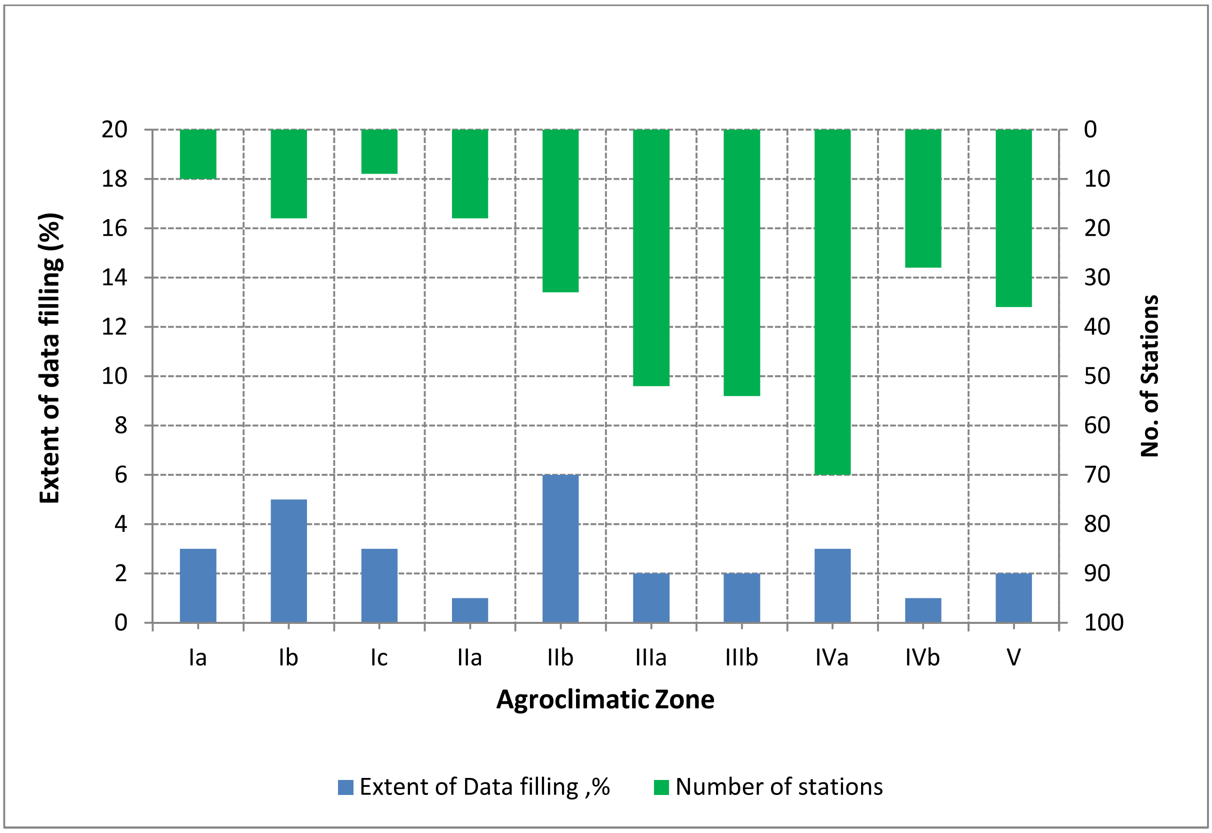


Figure 7.30 Percentages of Filled Records in ACZ Ia

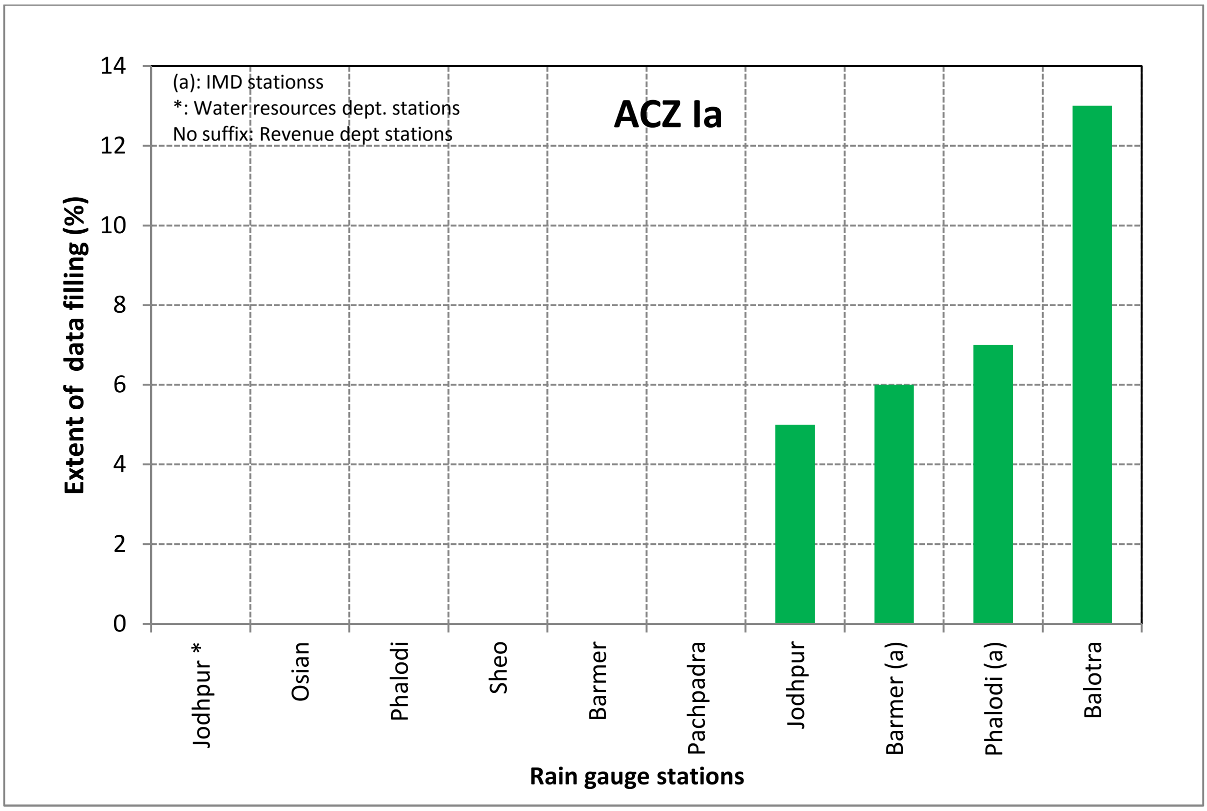


Figure 7.31 Percentage of Filled Records in ACZ Ib

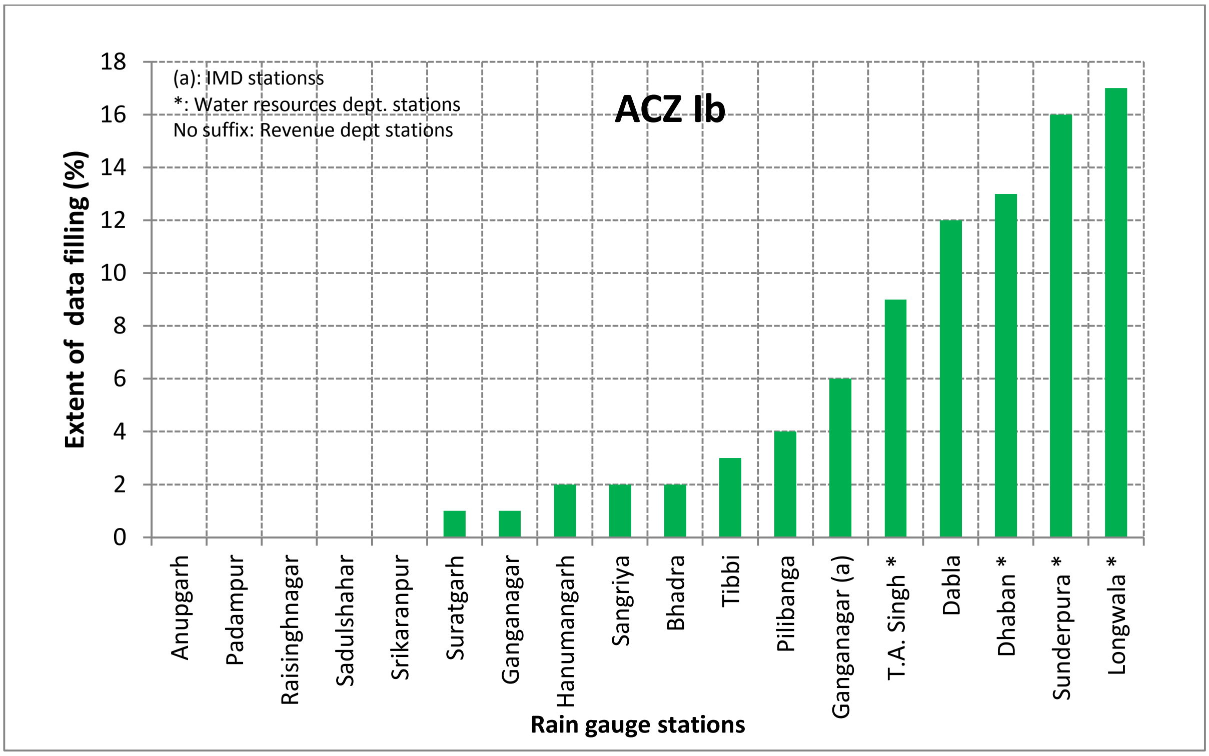


Figure 7.32 Percentage of Filled Records in ACZ Ic

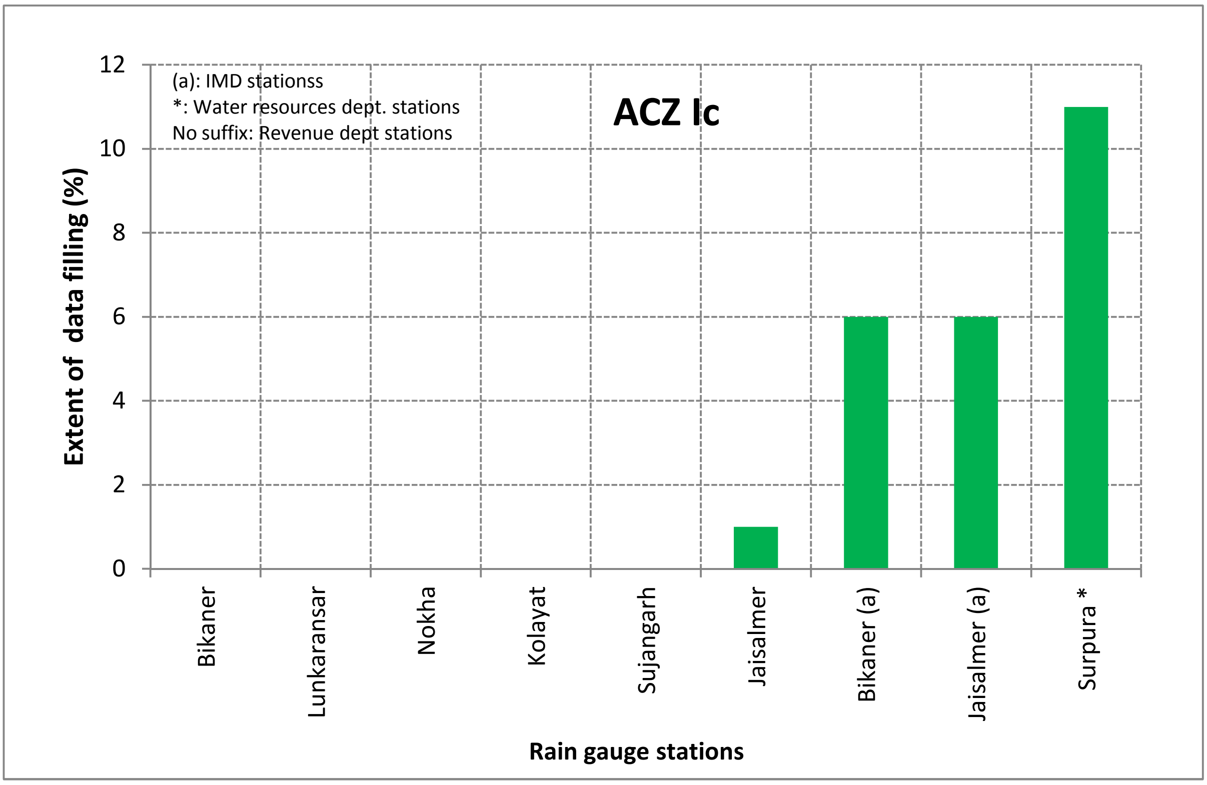


Figure 7.33 Percentage of Filled Records in ACZ IIa

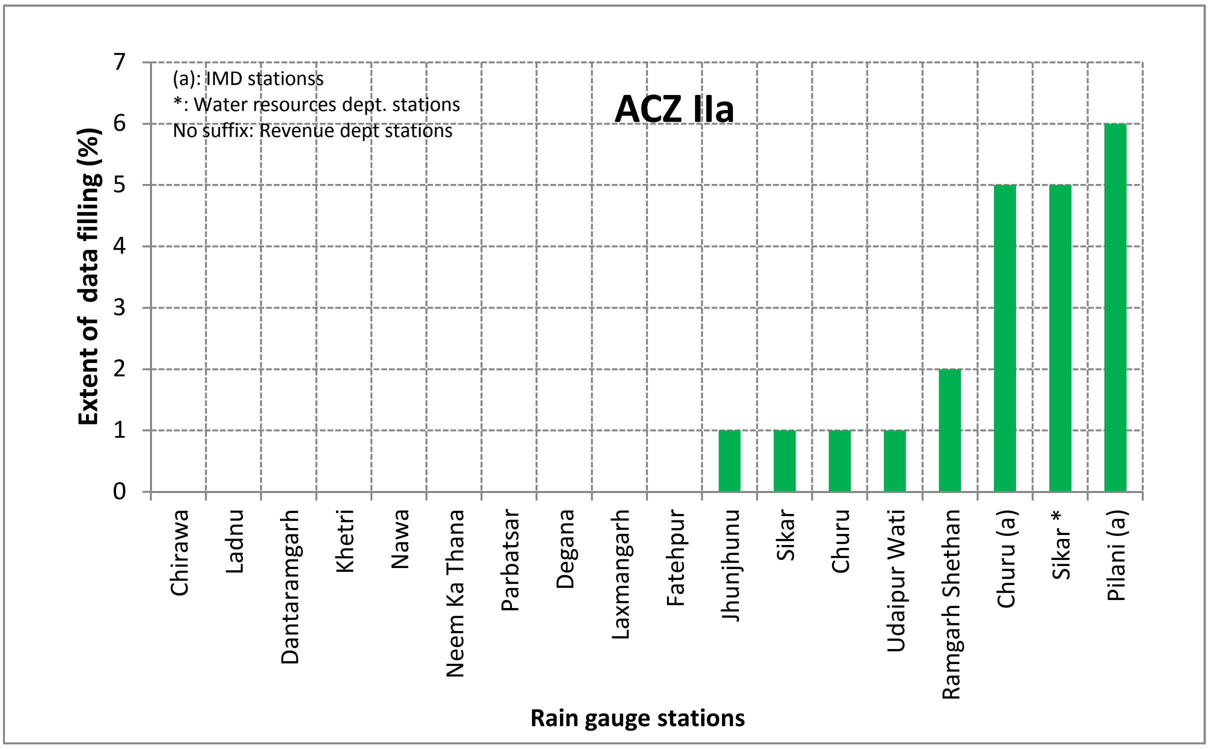


Figure 7.34 Percentage of Filled Records in ACZ IIb

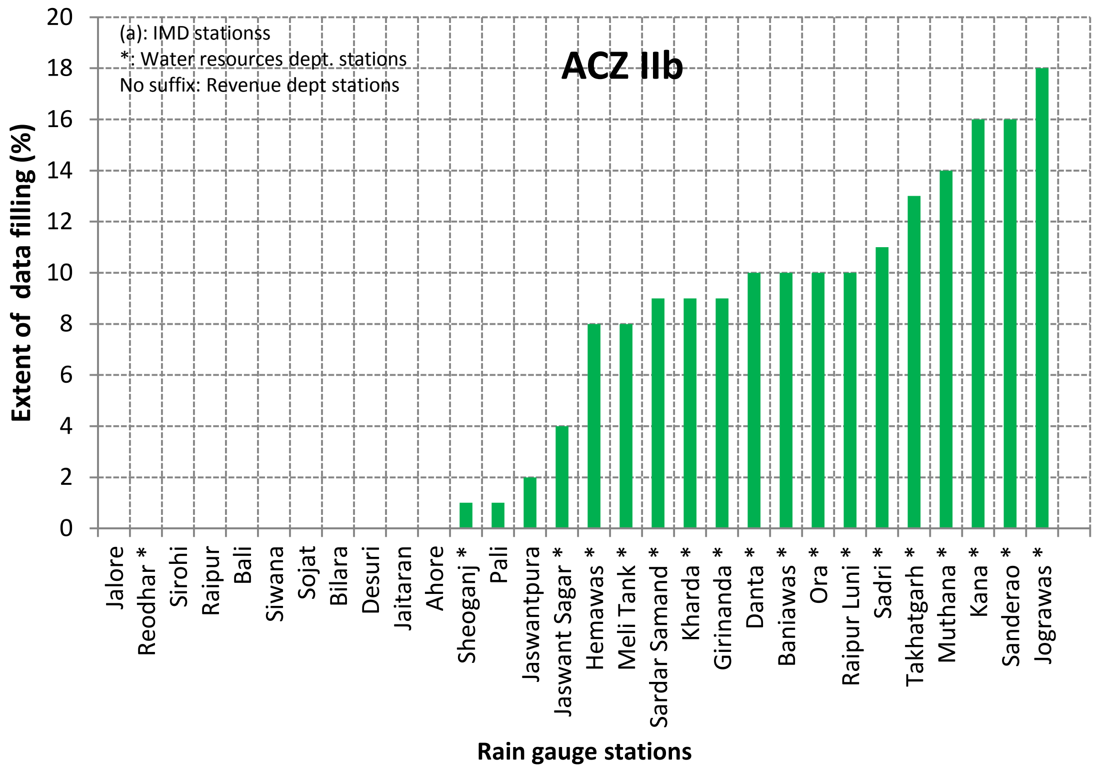


Figure 7.35 Percentage of Filled Records in ACZ IIIa

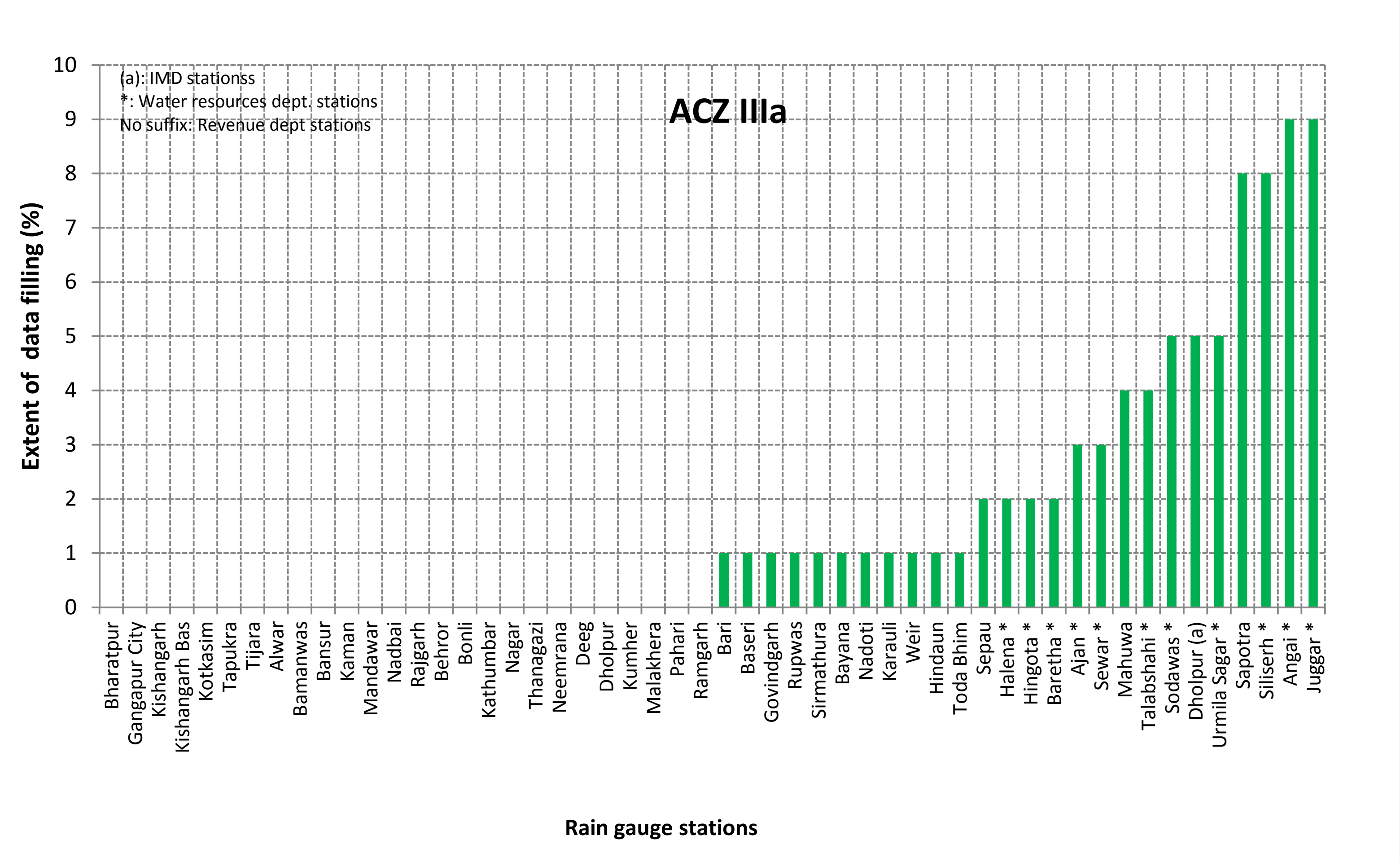


Figure 7.36 Percentage of Filled Records in ACZ IIIb

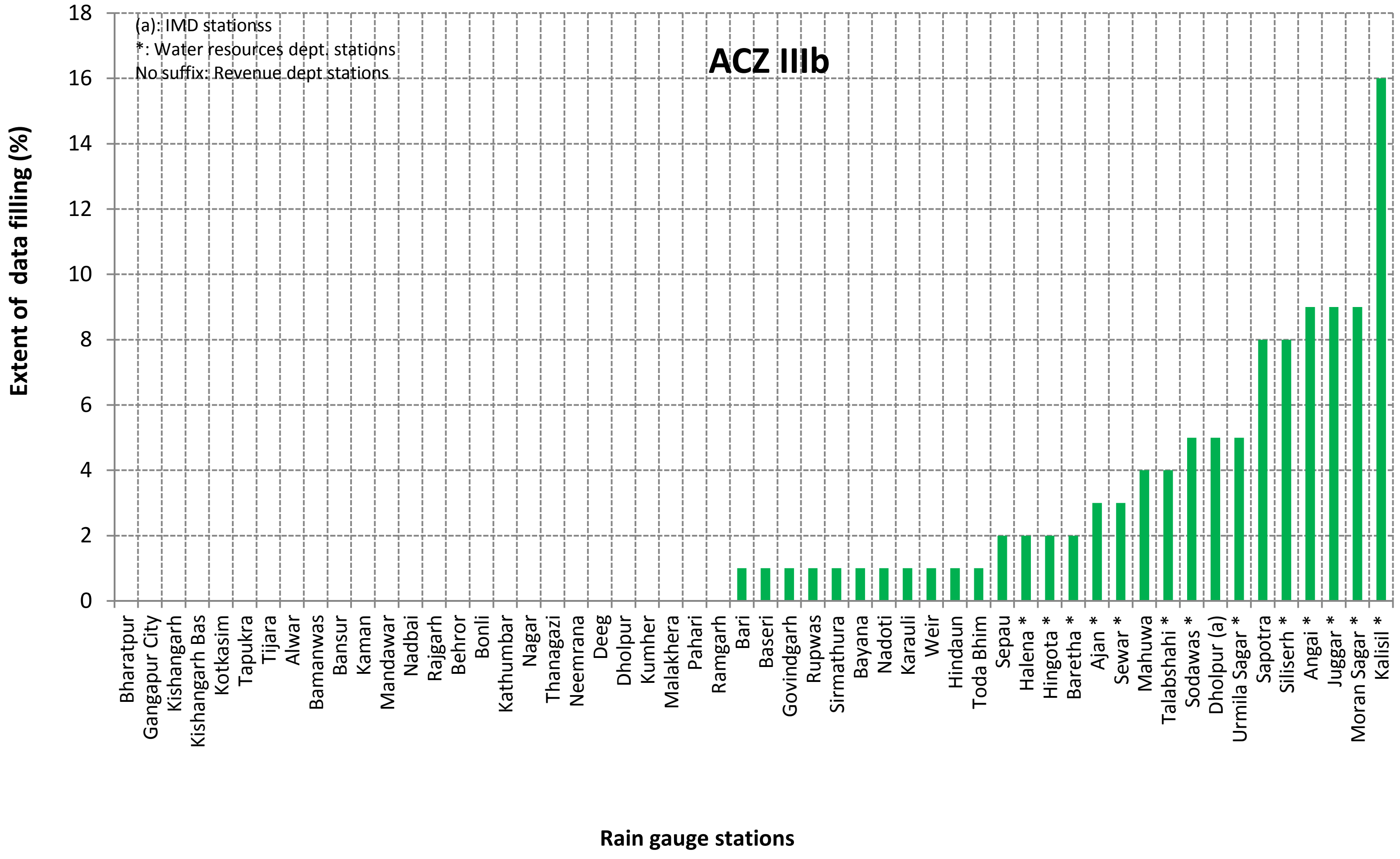


Figure 7.37 Percentage of Filled Records in ACZ IVa

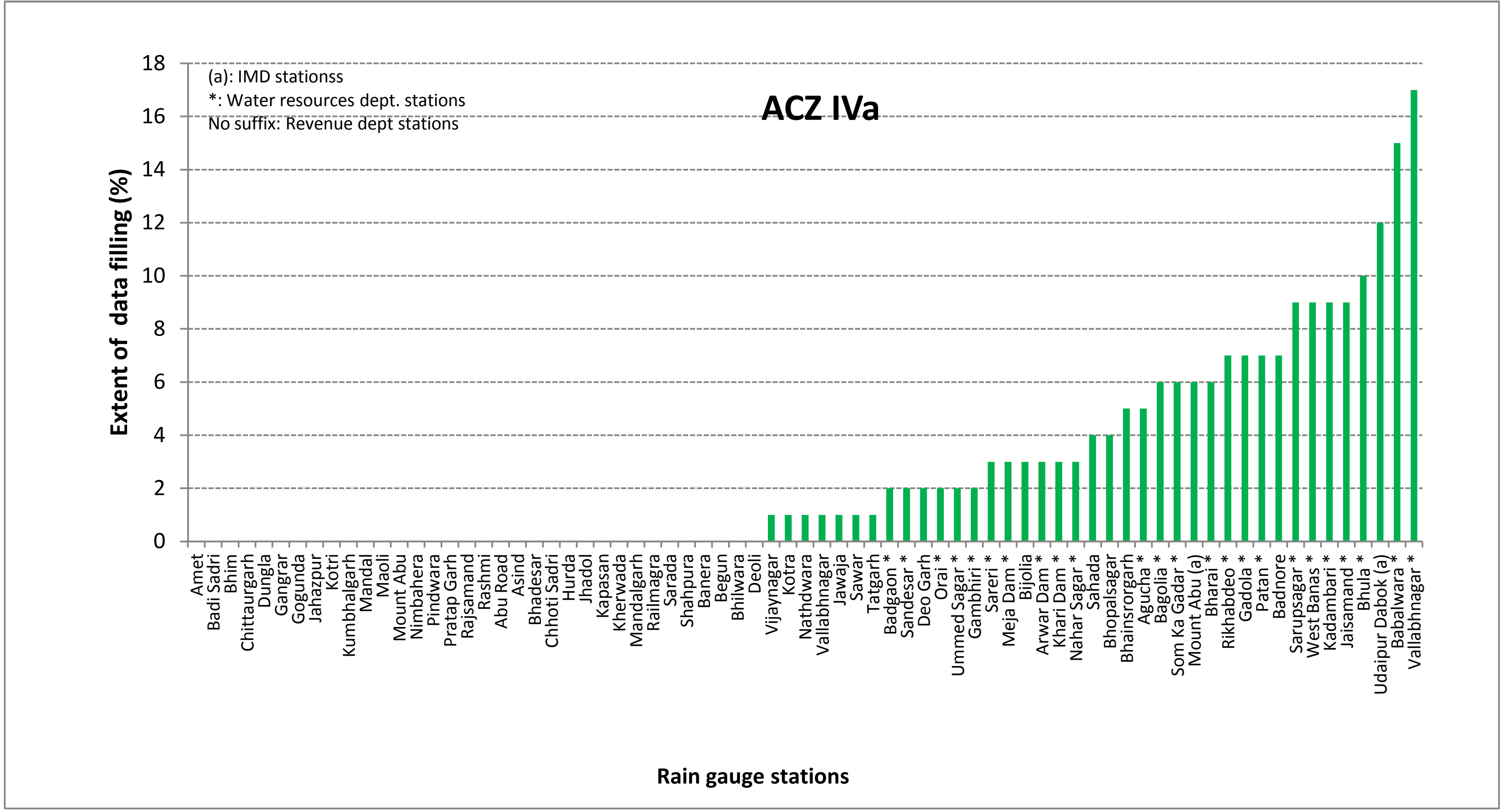


Figure 7.38 Percentage of Filled Records in ACZ IVb

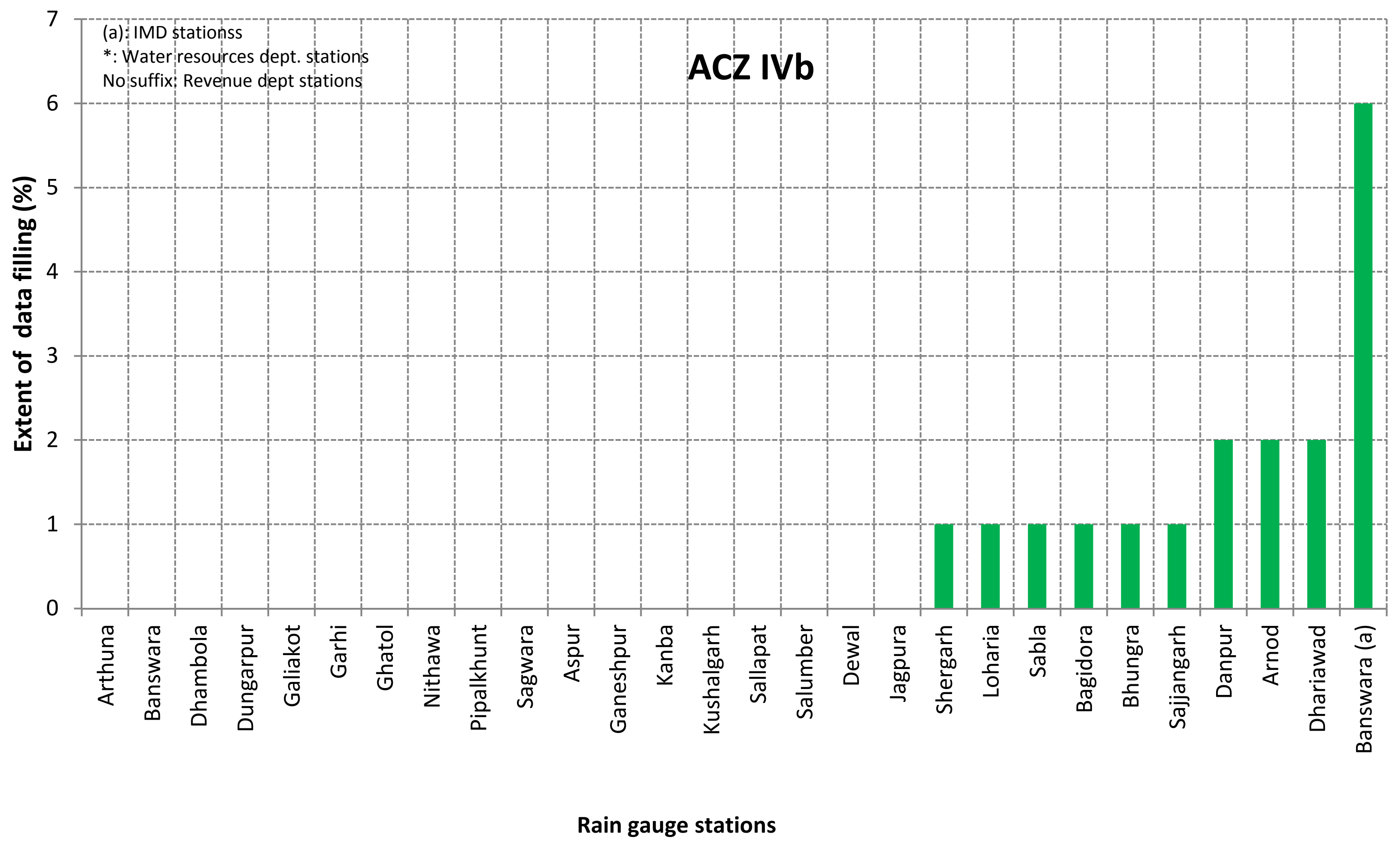


Figure 7.39 Percentage of Filled Records in ACZ V

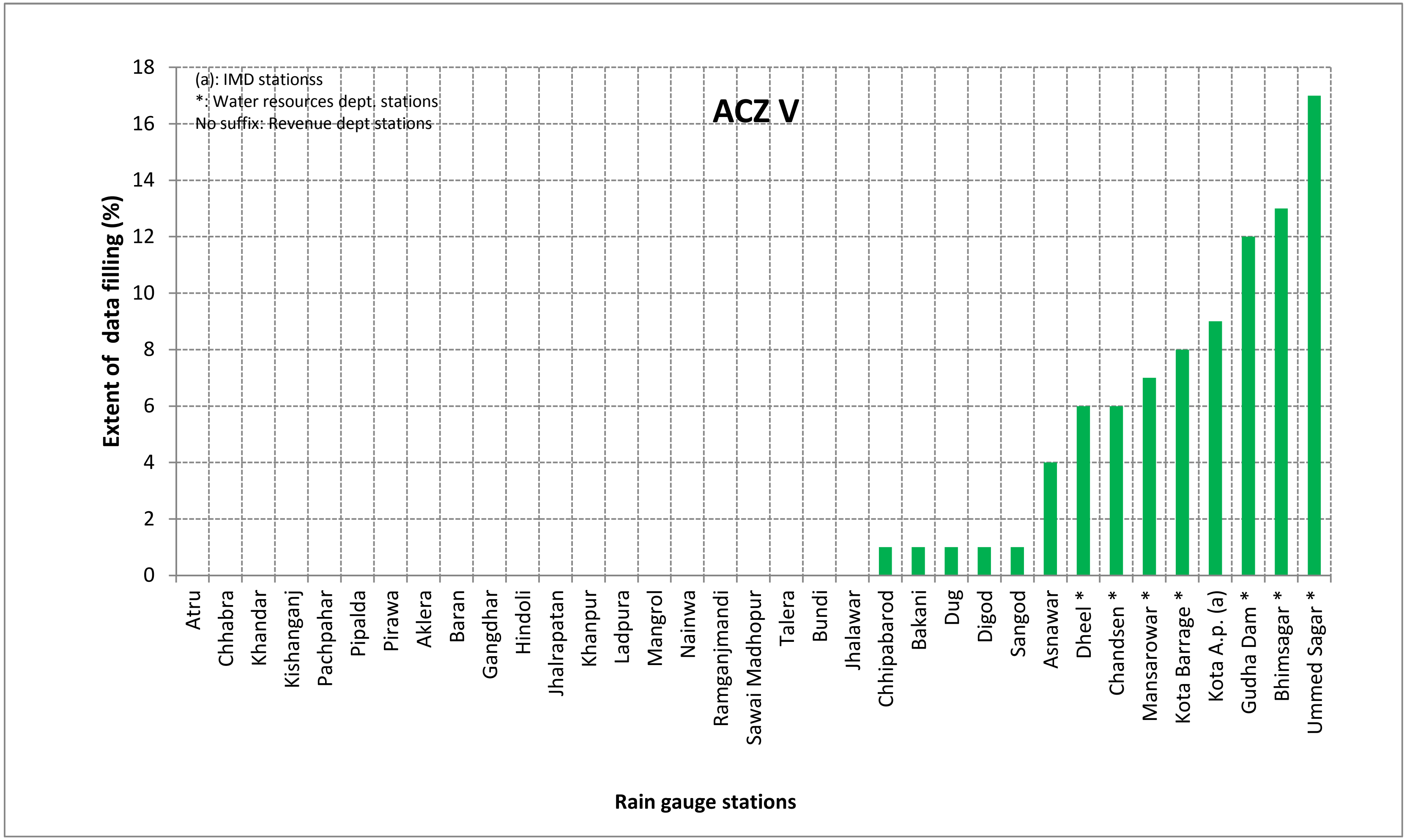
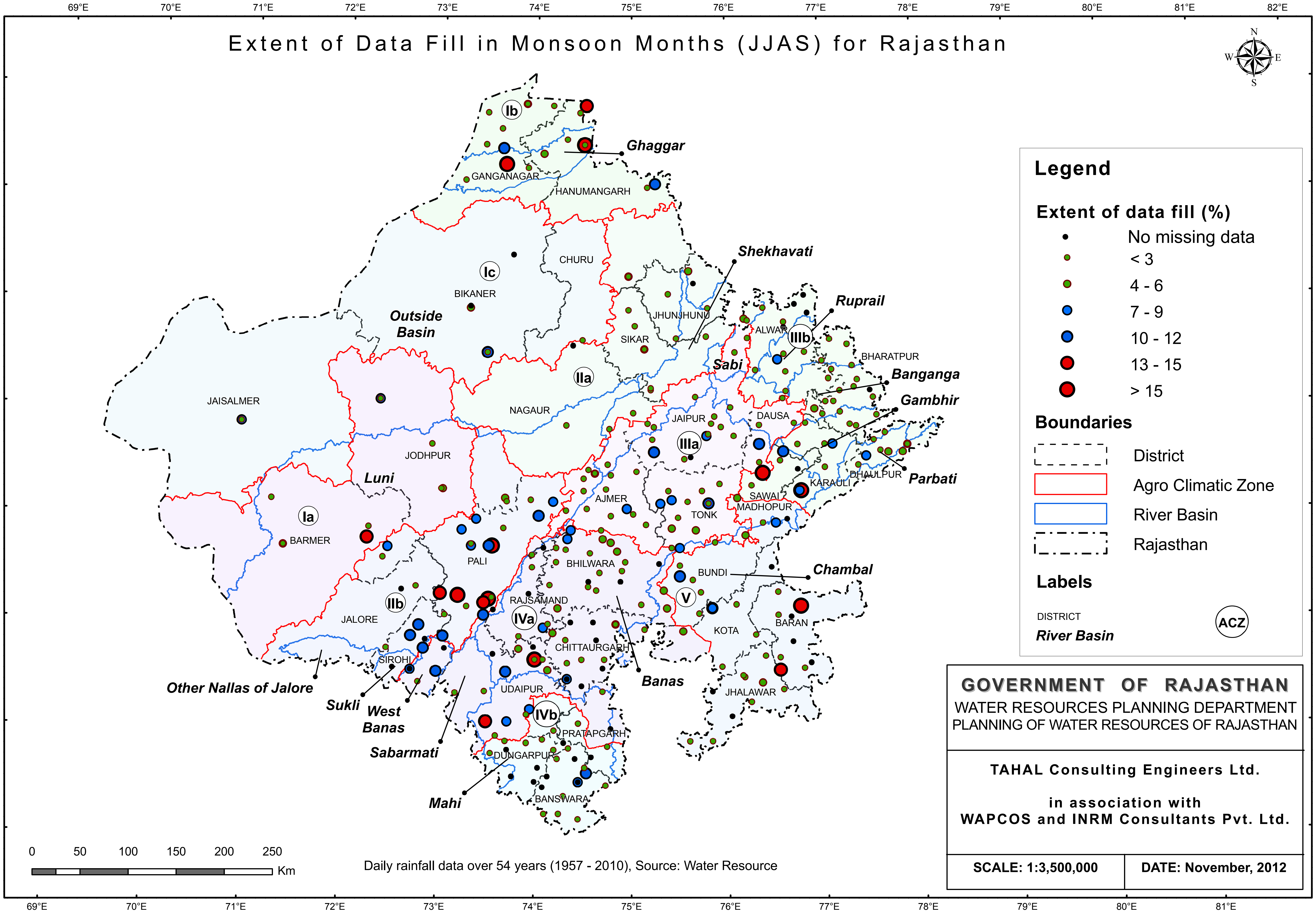


Figure 7.40

Extent of Data Fill in Monsoon Months (JJAS) for Rajasthan



Legend

Extent of data fill (%)

•	No missing data
●	< 3
●	4 - 6
●	7 - 9
●	10 - 12
●	13 - 15
●	> 15

Boundaries

▭	District
▭	Agro Climatic Zone
▭	River Basin
▭	Rajasthan

Labels

DISTRICT

River Basin

ACZ

Daily rainfall data over 54 years (1957 - 2010), Source: Water Resource

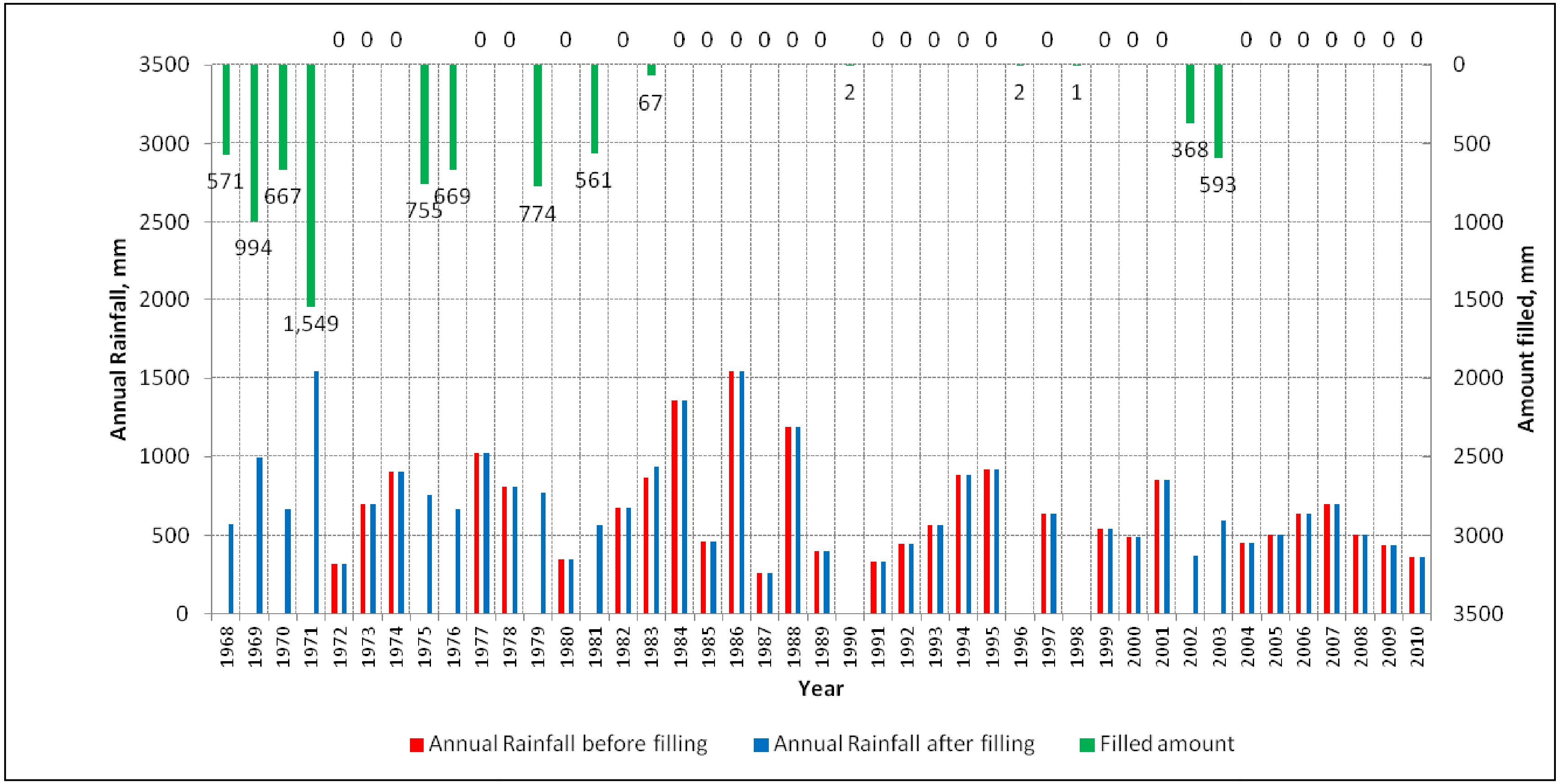
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:3,500,000	DATE: November, 2012

Figure 7.41 Filled Rainfall Data in Kota Barrage Station (WRIS Code 17)



7.10.3 Boxplot Analysis of Rainfall Records

a. Methodology

It is a challenge to analyze areas with tremendous rainfall variability as is the case in Rajasthan. Boxplots are commonly used for simultaneous visual comparisons of this kind of data and have therefore been employed in the present case. Boxplot analysis has been applied by the Consultants for analyzing and presentation of Rajasthan annual rainfall data of 54 years from 1957 to 2010, provided by the Water Resource Department, Jaipur for all the 10 agroclimatic zones (ACZs).

Raingauge stations are maintained by three departments: IMD (India Meteorology Department), WRD (Water Resources Department) and Revenue Department. Station names with suffix (a), with suffix “*” and with no suffix are maintained by IMD, WRD and Revenue Department, respectively.

The Boxplot computational tool is available as a public domain R-software, as discussed in the following paragraphs.

A Boxplot, or box and whisker diagram provides a simple graphical summary of a set of data. It is a graphical method of displaying five descriptive statistics:

- ✓ the median (50%),
- ✓ the upper (75%) and lower (25%) quartiles, and
- ✓ the minimum and maximum data values.

In addition, a Boxplot can help visualize two other elements:

- ✓ abnormal data (outliers)
- ✓ mean.

First created by John Tukey in a 1977 publication, Boxplots have evolved into a familiar and useful standard in data interpretation. Boxplots are powerful tools for picturing and comparing datasets as they give both a visual view and a numerical summary of a distribution. With larger sample sizes a Boxplot is an especially helpful tool, since it makes no distributional assumptions nor does it require any prior estimate of a mean or standard deviation. The plot may be drawn either vertically or horizontally.

The "box" itself represents the middle 50 percent of the data. The upper boundary (also known as the "hinge") of the box locates the 75th percentile of the data set while the lower boundary indicates the 25th percentile. The 25th percentile represents the value where 25 percent of the data is lower, and likewise, the 75th percentile represents the value where 75 percent of the data falls below. The area between these two boundaries is known as the "inter-quartile range" and it gives a useful indication of the "spread" of the middle 50 percent of the data. This is a more robust range for interpretation because the middle 50 percent is not affected by outliers or extreme values, and gives a less biased visualization of the data spread.

- ✓ If the median line within the box is not equidistant from the hinges then the data is skewed.
- ✓ The line in the box indicates the "median" (or central-most value) of the data. Not to be confused with the "mean", the median is the value in the middle of the data set

when the values are ranked in order, resulting in the same number of values above as below it. This is a measure of "central tendency", or in other words, where the centre of the data is.

- ✓ The "whiskers" of the box are the vertical lines of the plot extending from the box, and they indicate the minimum and maximum values in the dataset. If there are "outliers" in the data, the whiskers extend to their maximum of 1.5 times the inter-quartile range.

The points outside the ends of the whiskers are outliers or suspected outliers. In a box plot, outliers[8] are defined as being those values that are greater than Q3 + 1.5 × IQR (upper fence) or less than $Q1 - 1.5 \times IQR$ (lower fence)

The box, the whiskers, even the median can reveal much information about a dataset by virtue of their position, length, or size.

Boxplots analysis of 327 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010, for 10 agroclimatic zones is explained below. Analysis of each ACZ based on its stations has been carried out separately. It is important to note that the box, the whiskers and the median can reveal useful information about a functional dataset by looking at their position, size, length, and even the shape of the box or the median curve. Moreover, the spacing between the different parts of the box helps indicate the degree of skewness in the data and identify outliers.

The inter-quartile range provides important information on how variable the data is. For example, if a station has a relatively constant rainfall, the inter-quartile range would be relatively narrow, while if the rainfall was highly variable, the range would be relatively large. However, the mean is usually a poor measure of central tendency for rainfall data (i.e. data with a large number of relatively low values and a few extremely high values) because it is pulled (or skewed) away from the balance point by even a few very high values. The median (which equals the 50th percentile of the data) is generally the best measure of "central tendency" for rainfall data, and is indicated by a black horizontal line in the box. The mean is indicated by a blue triangle in the box. The outliers are shown as small red squares above and below the fences in boxplot graphs for these stations. The distance between the mean and the median is a good indication of how "skewed" the data is. If the mean is greater than median then data is positively skewed and vice versa.

The descriptive statistics of all ACZ stations used in construction of boxplots are given in Appendix 9 (Volume 2 of this report).

b. Boxplot Analysis of Annual Rainfall in ACZ Ia

Figure 7.42 depicts boxplots of 10 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone Ia.

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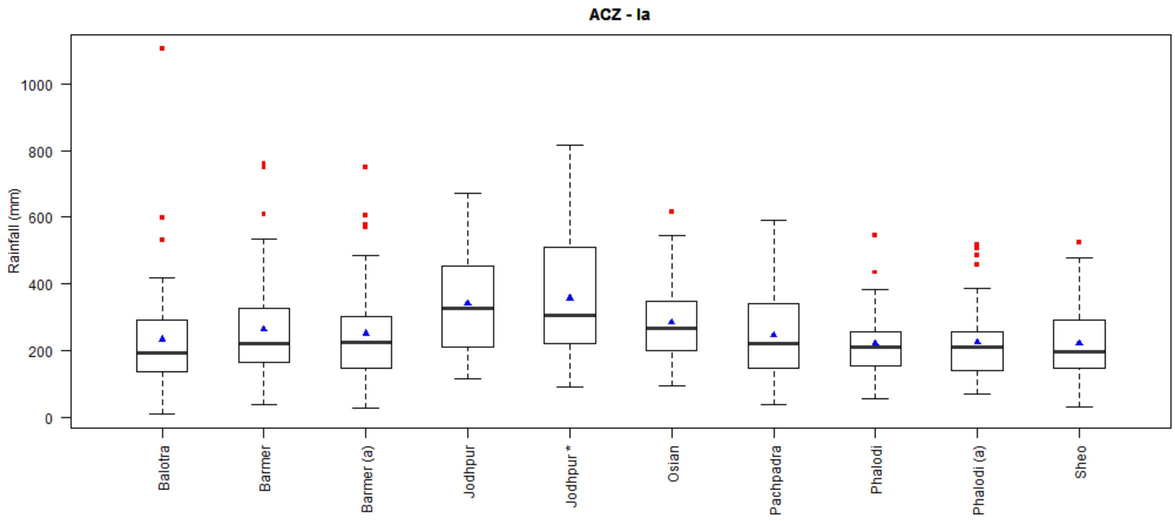
[8] "Outliers are observations that have extreme values relative to other observations observed under the same conditions. Observations may be outliers because of a single large or small value of one variable or because of an unusual combination of values of two or more variables." Source: 'Statistical Design and Analysis of Experiments', Mason, Gunst, and Hess.

Figure 7.42 Boxplots of Stations of Agroclimatic Zone Ia, Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 3 stations with normal rainfall as there are no outliers (as can be seen from the Figure 7.42). The details of 7 stations with outliers and their respective outlier years of rainfall are tabulated in Table 7.23.

Table 7.23 Results of Agroclimatic Zone Ia Annual Rainfall Analysis

Station WRIS code	Station Name	Years of Outliers	Annual Rainfall Values of Outlier Years , mm	Number of Upper Outliers	Number of Lower Outliers
354	Balotra	1975 1990# 1995	530.4 1106.0## 597.0	3	0
438	Barmer (a)	1961 1976 1990# 1994	578.2 570.0 750.5## 604.0	4	0
439	Barmer	1990 1994 2006#	748.2 608.0 759.0##	3	0
443	Sheo	1961	525.1	1	0
523	Phalodi (a)	1964# 1975 1976 1983	516.9## 505.0 456.0 486.0	4	0
524	Phalodi	1975 1983#	433.6 546.0##	2	0
536	Osian	1975	615.0	1	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

# - maximum upper outlier year

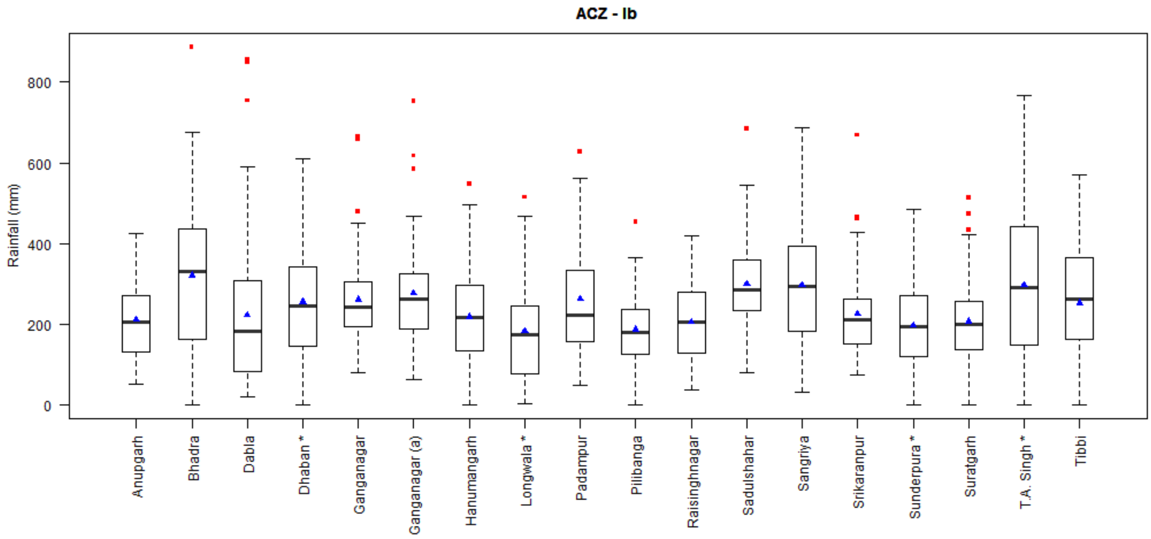
## - value of maximum upper outlier year

Source: WRD Daily Rainfall Data (1957-2010)

c. Boxplot Analysis of Annual Rainfall in ACZ Ib

Figure 7.43 depicts Boxplots of 18 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic Zone Ib.

Figure 7.43 Boxplots of Stations of Agroclimatic Zone Ib, Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 7 stations in ACZ Ib with normal rainfall, as there are no outliers observed (as can be seen from the Figure 7.43). The details of 11 stations with outliers and their respective outlier years of rainfall data are tabulated in Table 7.24. It is seen that 1976 is mostly an outlier year in this ACZ, as most of the stations have their maximum rainfall in this year.

Table 7.24 Results of Agroclimatic Zone Ib Annual Rainfall Analysis

Station WRIS Code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
460	Bhadra	1978	887.0	1	0
466	Dabla	2004 2006 $2010^{\#}$	754.0 850.0 $857.0^{\#\#}$	3	0
470	Ganganagar (a)	1958 $1976^{\#}$ 1983	617.5 $752.0^{\#\#}$ 584.4	3	0
471	Ganganagar	1976 $1983^{\#}$ 2007	658.7 $666.0^{\#\#}$ 479.0	3	0
475	Hanumangarh	2010	547.0	1	0
481	Srikaranpur	$1976^{\#}$ 1982 1997	$668.9^{\#\#}$ 464.0 461.0	3	0
484	Longwala *	2006	514.6	1	0
490	Padampur	2007	628.0	1	0
492	Pilibanga	1983	454.0	1	0
496	Sadulshahar	1976	684.0	1	0

Station WRIS Code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
502	Suratgarh	1976# 1983 2010	512.8## 473.5 434.0	3	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

# - maximum upper outlier year

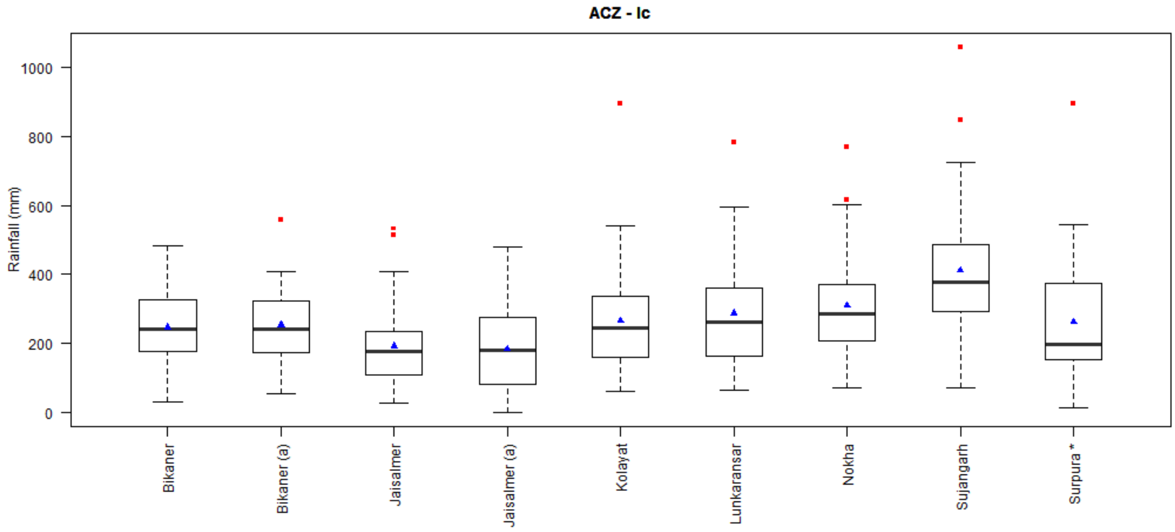
## - value of maximum upper outlier year

Source: WRD Daily Rainfall Data (1957-2010)

d. Boxplot Analysis of Annual Rainfall in ACZ Ic

Figure 7.44 depicts boxplots of 9 stations, based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010, in ACZ Ic.

Figure 7.44 Boxplots of Stations of ACZ Ic, Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 2 (a) stations, Bikaner and Jaisalmer in ACZ-Ic with normal rainfall - no outliers observed (as can be seen from Figure 7.44). The other 7 stations are outlying with respect to their respective rainfall regions, as detected by enhanced boxplots. The details of 7 stations with outliers and their respective outlier rainfall years are tabulated in Table 7.25. The largest number of upper outliers observed in any station is 2.

Table 7.25 Results of Agroclimatic Zone Ic Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
444	Bikaner (a)	1983	558.5	1	0
446	Lunkaransar	2010	783.0	1	0
447	Kolayat	1997	894.0	1	0
449	Nokha	1975# 1996	769.4## 616.0	2	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
456	Sujangarh	1975 1977$^{\#}$	845.5 1057.7$^{\#\#}$	2	0
511	Jaisalmer	1961$^{\#}$ 2006	532.2$^{\#\#}$ 512.8	2	0
526	Surpura*	1997	894.0	1	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

$^{\#}$ - maximum upper outlier year

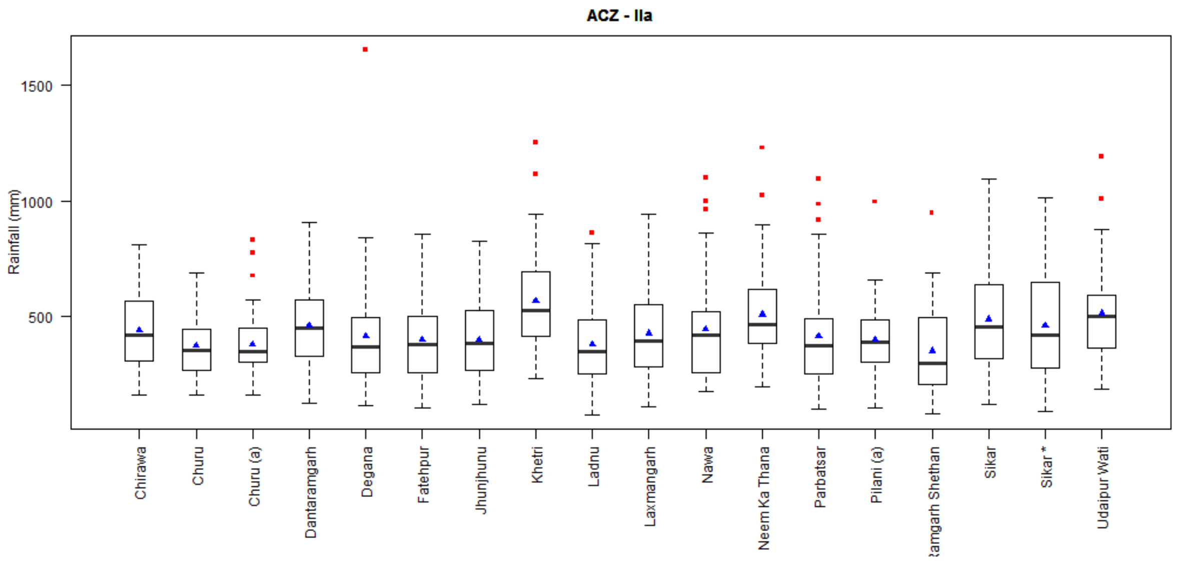
$^{\#\#}$ - value of maximum upper outlier year

Source: WRD Daily Rainfall Data (1957-2010)

e. Boxplot Analysis of Annual Rainfall in ACZ IIa

Figure 7.45 depicts Boxplots of 18 stations based on Rajasthan Annual Rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone IIa.

Figure 7.45 Boxplots of Stations of Agroclimatic Zone IIa, Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 8 stations with normal rainfall, as there are no outliers observed (as can be seen from Figure 7.45). The details of 10 stations with outliers and their respective outlier years of rainfall are tabulated in Table 7.26. It is seen that 1975 and 1977 are mostly observed as outlier years in ACZ IIa, as most of the stations have their maximum rainfall in these years.

Table 7.26 Results of Agroclimatic Zone IIa Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
339	Degana	1975	1652.0	1	0
420	Khetri	1977$^{\#}$ 1996	1252.4$^{\#\#}$ 1115.0	2	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
421	Neem Ka Thana	1977 2010#	1024.0 1229.0##	2	0
422	Udaipur Wati	1995 1996#	1010.0 1191.0##	2	0
430	Nawa	1971 1975# 1977	996.7 1098.0## 964.9	3	0
431	Parbatsar	1975# 1996 2010	1096.5## 985.5 917.0	3	0
433	Ramgarh Shethan	2010	950.0	1	0
437	Pilani (a)	1978	996.1	1	0
450	Churu (a)	1964 1977 1978#	677.7 777.2 831.2##	3	0
529	Ladnu	1975	860.2	1	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

- maximum upper outlier year

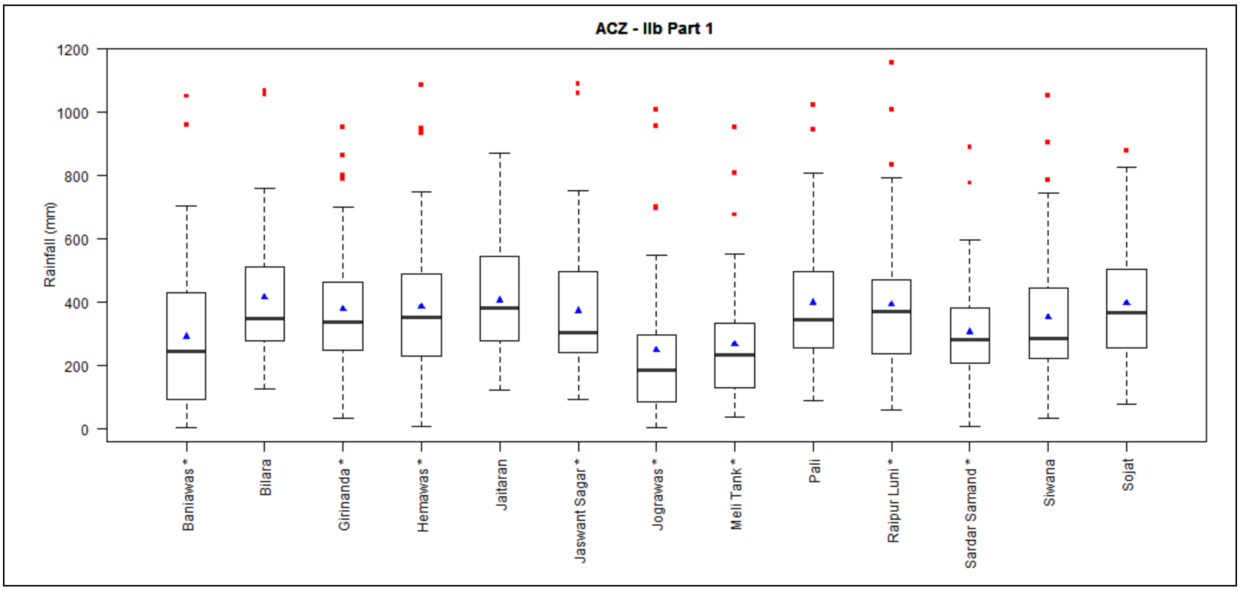
## - value of maximum upper outlier year

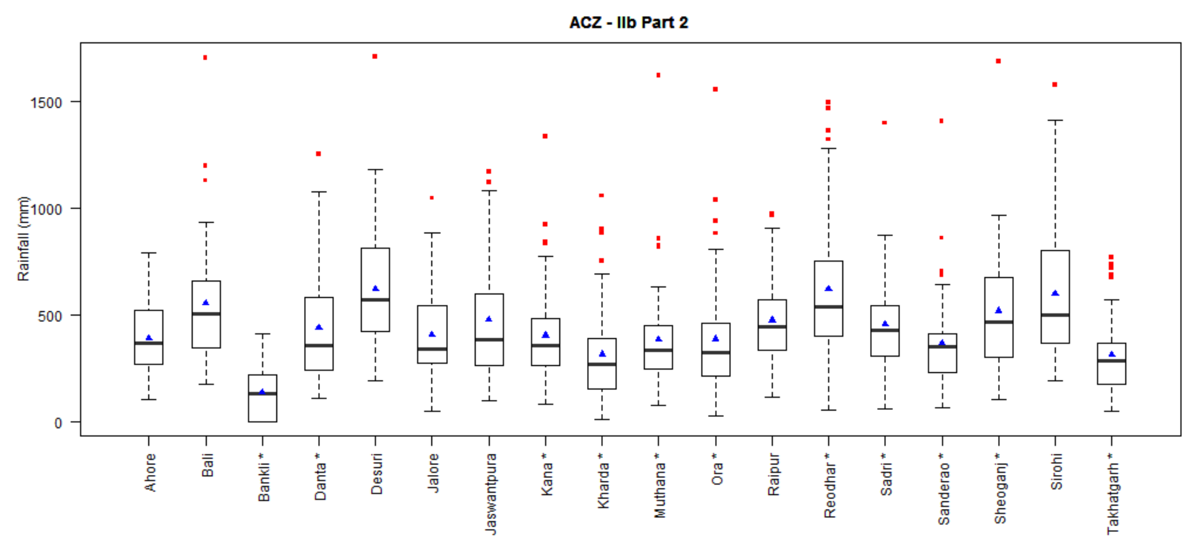
Source: WRD Daily Rainfall Data (1957-2010)

f. Box-plot Analysis of Annual Rainfall in ACZ-IIb

Figure 7.46 depicts Boxplots of 31 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone IIb.

Figure 7.46 Boxplots of Stations of Agroclimatic Zone IIb, Based on Annual Rainfall Data of 1957-2010





It may be observed that there are 3 stations with normal rainfall, as there are no outliers observed (as can be seen from the Figure 7.46). The details of 28 stations with outliers and their respective outlier rainfall years are tabulated in Table 7.27. It is seen that 1973 and 1990 are mostly observed as outlier years in ACZ IIb, as most of the stations have their extreme rainfall in these years.

Table 7.27 Results of Agroclimatic Zone IIb Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
341	Girinanda *	1975 $1976^{\#}$ 1979 1983	1574.0 $1904.0^{\#\#}$ 1602.0 1725.4	4	0
349	Meli Tank *	1973 1975 $1990^{\#}$	1617.0 1352.0 $1904.7^{\#\#}$	3	0
351	Siwana	1961 1973 $1990^{\#}$	1808.6 1570.4 $2104.0^{\#\#}$	3	0
353	Jaswant Sagar *	$1975^{\#}$ 1979	$2176.0^{\#\#}$ 2119.6	2	0
355	Bilara	1975 $1979^{\#}$	2113.0 $2136.0^{\#\#}$	2	0
359	Raipur	$1983^{\#}$ 2010	$972.4^{\#\#}$ 967.0	3	0
360	Raipur Luni *	$1976^{\#}$ 1983 1999	$2312.0^{\#\#}$ 1667.5 2017.6	3	0
361	Sardar Samand *	1975 $1979^{\#}$	1552.0 $1779.0^{\#\#}$	2	0
362	Sojat	1994	1757.8	1	0
363	Baniawas *	1979 $1980^{\#}$	1920.8 $2100.8^{\#\#}$	2	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
365	Jograwas *	1975 1979 1980[#] 1992	1395.8 1912.3 2017.5[##] 1402.7	4	0
371	Hemawas *	1973 1979[#] 1990	1898.0 2170.0[##] 1865.7	3	0
372	Pali	1979 1990[#]	1886.8 2044.8[##]	2	0
374	Desuri	1973	3420.2	1	0
375	Kharda *	1967 1973[#] 1979 1980	1506.0 2116.0[##] 1770.0 1804.2	4	0
379	Kana *	1967 1973[#] 1983 1992	1846.0 2669.4[##] 1668.3 1683.4	4	0
380	Muthana *	1967 1973[#] 1983 2006	1636.8 3240.0[##] 1714.3 1645.9	4	0
382	Sadri *	1973	2797.3	1	0
388	Sanderao *	1961 1967 1973[#] 1983	1404.0 1377.0 2818.2[##] 1719.9	4	0
389	Takhatgarh *	1967 1973 1983 2003 2006[#]	1477.6 1374.8 1444.0 1350.8 1539.2[##]	5	0
409	Danta *	1973	2506.0	1	0
410	Ora *	1961 1973[#] 1975 1992	1764.0 3116.0[##] 2080.0 1882.0	4	0
411	Sirohi	1973	3155.2	1	0
413	Jaswantpura	1973[#] 1992	2344.0[##] 2240.0	2	0
543	Jalore	1990	2094.8	1	0
547	Sheoganj *	1973	3378.8	1	0
548	Reodhar *	1973[#] 1976 1990 1994 2006	2992.2[##] 2721.6 2935.0 2732.0 2644.0	5	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
561	Bali	1973[#] 1990 2006	3411.0[##] 2400.4 2260.8	3	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

[#] - maximum upper outlier year

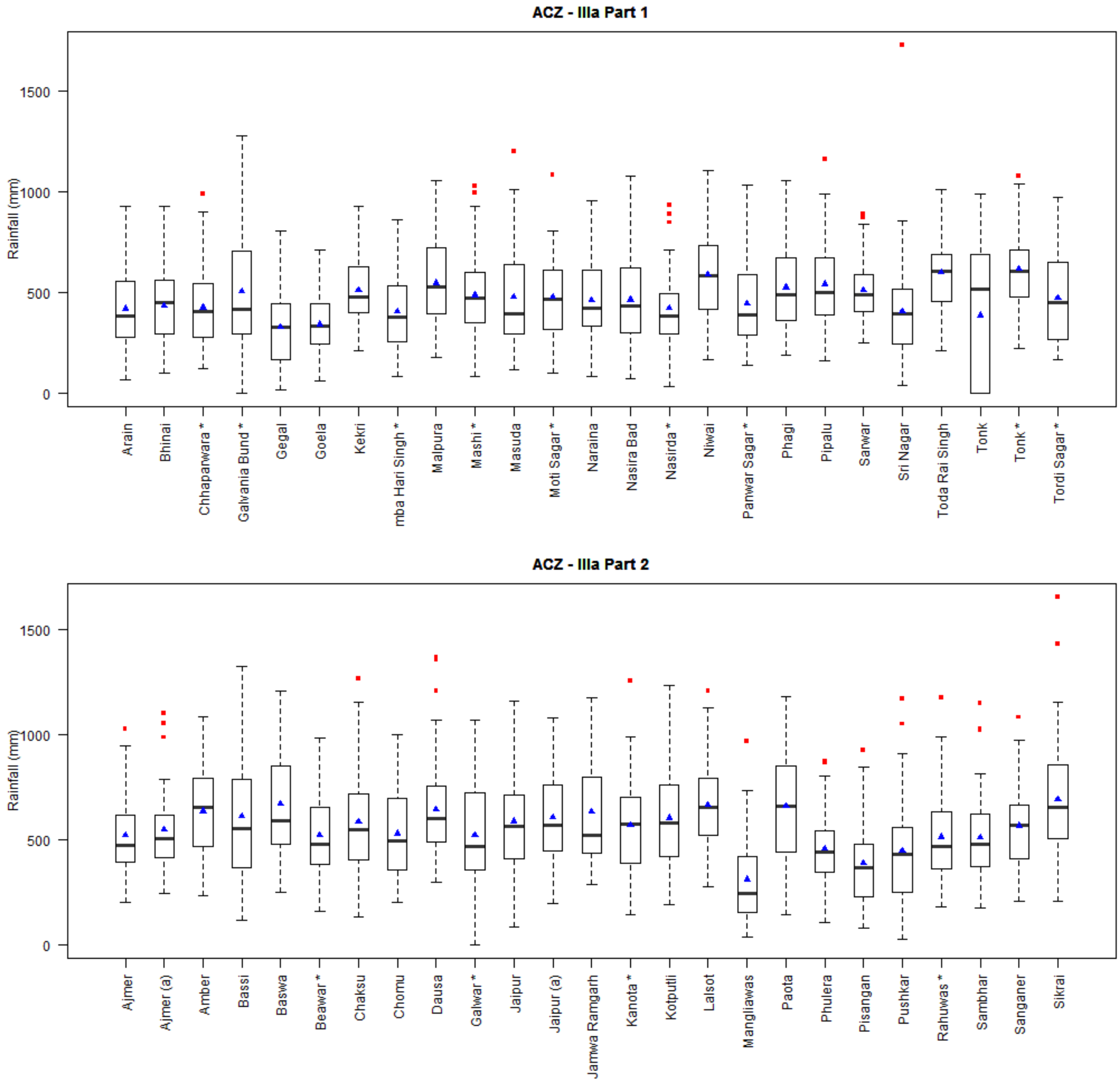
[##] - value of maximum upper outlier year

Source: WRD Daily Rainfall Data (1957-2010)

g. Boxplot Analysis of Annual Rainfall in ACZ IIIa

Figure 7.47 depicts Boxplots of 50 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone IIIa.

Figure 7.47 Boxplots of Stations of Agroclimatic Zone IIIa Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 26 stations with normal rainfall, as there are no outliers observed (as can be seen from the Figure 7.47). The details of 24 stations with outliers and their respective outlier years of rainfall are tabulated in Table 7.28. It is seen that 1975 and 1976 are mostly observed as outlier years in ACZ IIIa, as most of the stations have their extreme rainfall in these years.

Table 7.28 Results of Agroclimatic Zone IIIa Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
127	Moti Sagar *	1976	2170.0	1	0
128	Nasirda *	1971 1973# 1975	1783.2 1870.0## 1698.0	3	0
133	Tonk *	1996	2156.0	1	0
136	Masuda	1997	2400.0	1	0
160	Sarwar	1973# 1975	1784.6## 1752.0	2	0
161	Sri Nagar	1976	3462.0	1	0
165	Chhaparwara *	1975	1980.0	1	0
176	Mashi *	1971# 1975	2063.2## 1992.0	2	0
177	Pipalu	2010	2330.0	1	0
182	Chaksu	1961	2527.2	1	0
186	Kanota *	1981	2504.2	1	0
187	Lalsot	1977	2414.0	1	0
188	Rahuwas *	1981	2347.2	1	0
190	Sanganer	1981	2161.8	1	0
221	Dausa	1975# 1981 1983	2726.4## 2413.6 2706.4	3	0
226	Sikrai	1978 1995#	2859.2 3304.0##	2	0
344	Mangliawas	1976	1932.0	1	0
345	Pisangan	1983	1850.0	1	0
346	Pushkar	2003 2010#	2098.0 2334.0##	2	0
406	Morel Dam *	1981	2504.8	1	0
423	Ajmer (a)	1975# 1976 1983	2203.4## 1970.2 2101.2	3	0
424	Ajmer	1997	2052.2	1	0
427	Phulera	1996 2010#	1732.0 1744.0##	2	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
428	Sambhar	1975$^{\#}$ 1983 1996	2293.8$^{\#\#}$ 2043.6 2048.2	3	0

(a) = IMD stations. *= Water Resources Dept. Stations. No suffix = Revenue Dept. stations

$^{\#}$= maximum upper outlier year

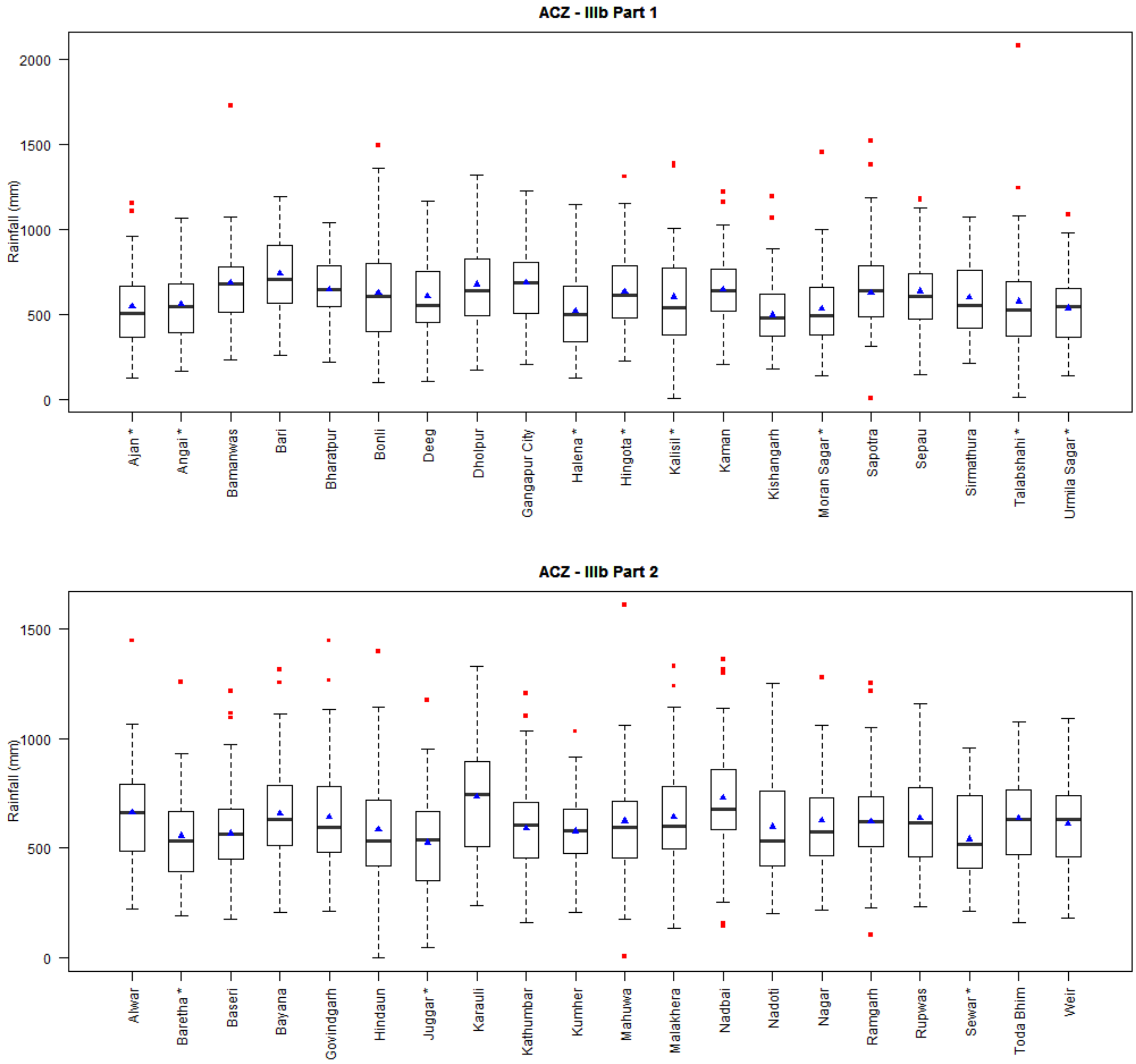
$^{\#\#}$= value of maximum upper outlier year

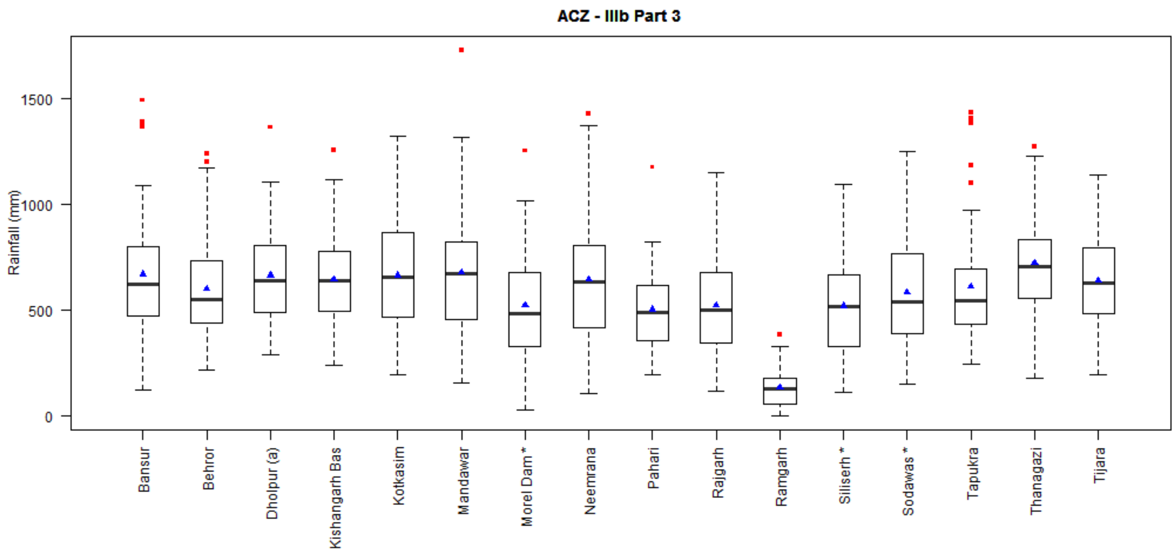
Source: WRD Daily Rainfall Data (1957-2010)

h. Boxplot Analysis of Annual Rainfall in ACZ IIIb

Figure 7.48 depicts Boxplots of 56 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010, in Agro-Climatic Zone IIIb.

Figure 7.48 Boxplots of Stations of Agroclimatic Zone IIIb Based on Annual Rainfall Data of 1957-2010





It may be observed that there are 20 stations with normal rainfall as there are no outliers observed (as can be seen from Figure 7.48). The details of 36 stations with outliers and their respective outlier rainfall years are tabulated in Table 7.29. It is seen that 1958, 1995 and 1996 are mostly observed as outlier years in ACZ IIIb, as most of the stations have their extreme rainfall in these years.

Table 7.29 Results of Agroclimatic Zone IIIb Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
9	Urmila Sagar *	1961	2165.6	1	0
158	Kishangarh	1975 1997[#]	2132.0 2386.0[##]	2	0
192	Bamanwas	1981	3454.0	1	0
193	Bonli	1983	2987.6	1	0
196	Moran Sagar *	1995	2904.0	1	0
197	Kalisil *	1977[#] 1995	2768.0[##] 2747.2	2	0
198	Sapotra	1968[###] 1971[###] 1973[###] 1975[###] 1977 1995[#] 1998[###]	9.3[####] 15.9[####] 11.3[####] 17.2 [####] 2758.2 3038.0[##] 14.1[####]	2	5
202	Sepau	1958[#] 1976	2364.2[##] 2336.0	2	0
204	Talabshahi *	1967 1975[#]	2483.2 4157.2[##]	2	0
206	Ajan *	1982 1995[#]	2208.6 2304.0[##]	2	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
211	Hingota *	1996	2615.4	1	0
212	Kaman	1977 1996$^{\#}$	2312.4 2438.4$^{\#\#}$	2	0
213	Kumher	1958	2063.2	1	0
214	Nadbai	1958$^{\#}$ *1978*$^{\#\#\#}$ *1979*$^{\#\#\#}$ 1982 1984	2717.2$^{\#\#}$ *289.8*$^{\#\#\#\#}$ *310.6*$^{\#\#\#\#}$ 2628.4 2598.0	3	2
215	Nagar	1967 1996$^{\#}$	2549.4 2554.0$^{\#\#}$	2	0
228	Mahuwa	*1962*$^{\#\#\#}$ 1995$^{\#}$ 1996	*11.2*$^{\#\#\#\#}$ 3216.0$^{\#\#}$ 3214.0	2	1
230	Baretha *	1995	2516.0	1	0
231	Bayana	1958 1995$^{\#}$	2507.8 2628.0$^{\#\#}$	2	0
233	Baseri	1957 1958$^{\#}$ 2008	2228.4 2432.2$^{\#\#}$ 2186.0	3	0
235	Hindaun	1961	2792.6	1	0
236	Juggar *	1975 1995$^{\#}$	2344.6 2350.0$^{\#\#}$	2	0
243	Alwar	1996	2890.2	1	0
244	Govindgarh	1996$^{\#}$ 2010	2890.0 $^{\#\#}$ 2528.0	2	0
245	Kathumbar	1995 1996$^{\#}$	2202.0 2412.0$^{\#\#}$	2	0
247	Malakhera	1996$^{\#}$ 2008	2656.0 $^{\#\#}$ 2476.0	2	0
248	Ramgarh	*1968*$^{\#\#\#}$ 1996 2010$^{\#}$	*210.0*$^{\#\#\#\#}$ 2432.0 2502.0$^{\#\#}$	2	1
251	Thanagazi	1996	2544.0	1	0
252	Bansur	1977 1983$^{\#}$ 1996	2771.4 2979.2$^{\#\#}$ 2730.0	3	0
253	Behror	1977 1996$^{\#}$	2396.0 2476.0$^{\#\#}$	3	0
254	Kishangarh Bas	1996	2506.0	1	0
256	Mandawar	1995	3452.0	1	0
257	Neemrana	1977	2849.0	1	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
259	Tapukra	1977 1983# 1985 1995 1996	2768.0 2868.0## 2810.2 2364.0 2196.0	5	0
406	Morel Dam *	1981	2504.8	1	0
541	Pahari	1996	2348.0	1	0
673	Dholpur (a)	1967	2724.6	1	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

# - maximum upper outlier year

## - value of maximum upper outlier year

### - lower outlier year

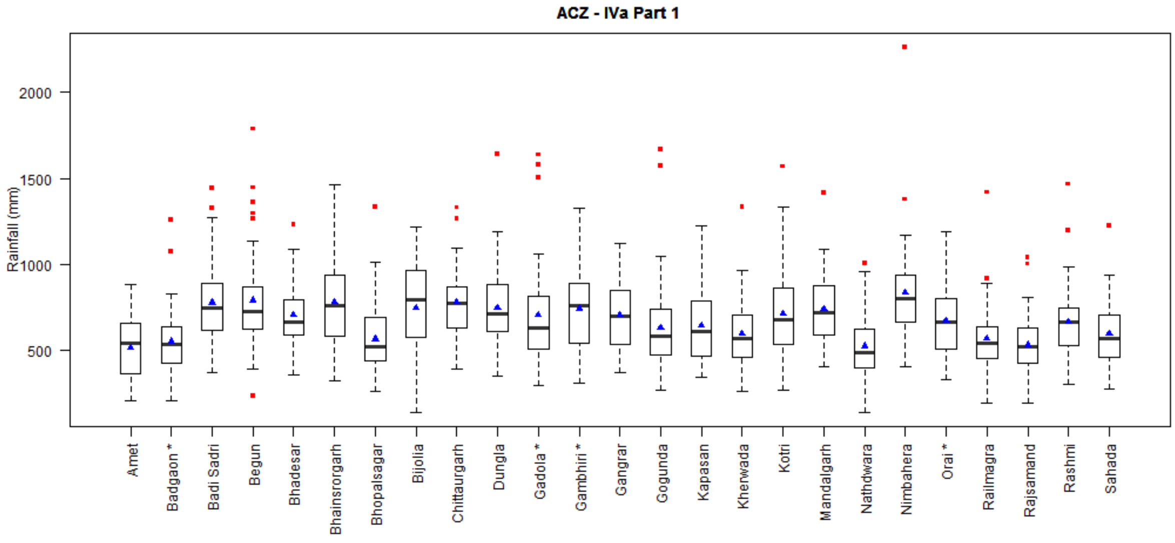
#### - value of lower outlier year

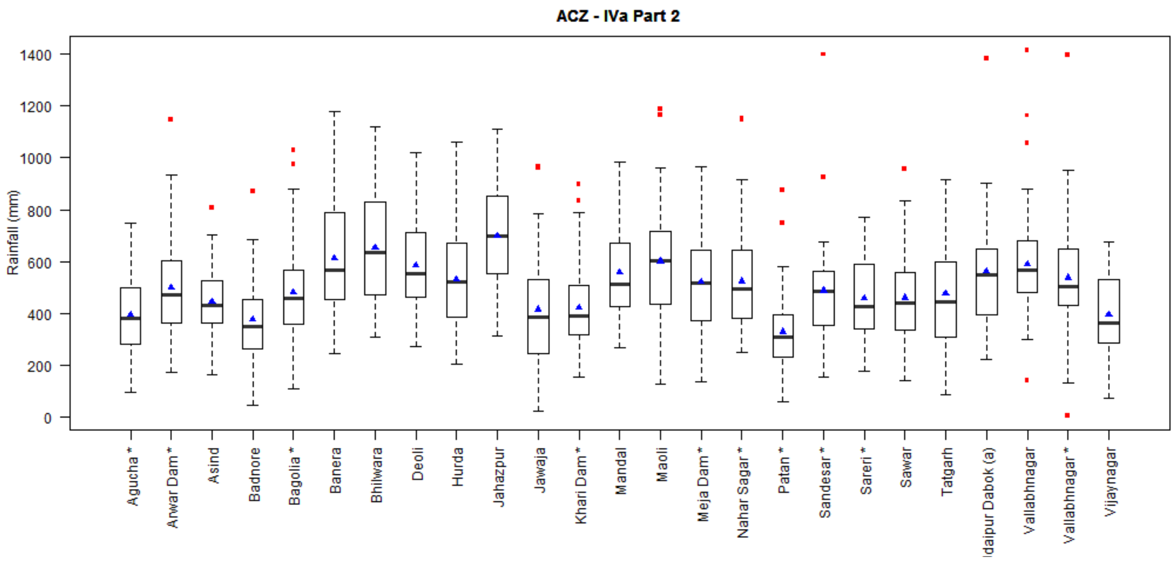
Source: WRD Daily Rainfall Data (1957-2010)

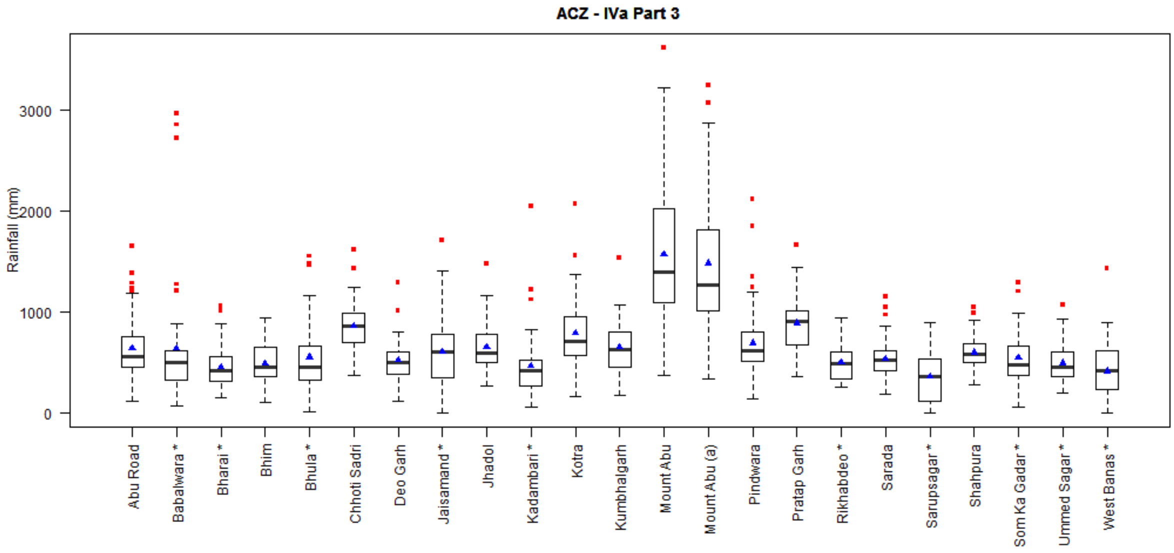
i. Boxplot Analysis of Annual Rainfall in ACZ IVa

Figure 7.49 depicts Boxplots of 73 stations based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010, in agroclimatic zone IVa.

Figure 7.49 Boxplots of Stations in Agroclimatic Zone IVa, Based on Annual Rainfall Data of 1957 to 2010







It may be observed that there are 21 stations with normal rainfall, as there are no outliers observed (as can be seen from Figure 7.49). The details of 52 stations with outliers and their respective outlier years of rainfall are tabulated in Table 7.30. It is seen that 1973 and 2006 are mostly observed as outlier years in ACZ IVa, as most of the stations have their extreme rainfall in these years.

Table 7.30 Results of Agroclimatic Zone IVa Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
5	Begun	1986 1994 2002[###] 2006 2008 2010[#]	1358.0 1296.0 231.0[####] 1446.0 1267.0 1788.0[##]	5	1

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
6	Gadola *	1973[#] 1994 2006	1637.2[##] 1580.0 1502.0	3	0
68	Mandalgarh	1994	1414.0	1	0
69	Kotri	1996	1569.0	1	0
70	Sahada	1973	1226.0	1	0
72	Rashmi	1970 1973[#]	1198.6 1465.7[##]	2	0
76	Gogunda	1973 2006[#]	1575.0 1670.0[##]	2	0
77	Kherwada	2006	1332.0	1	0
78	Nathdwara	1973[#] 2005	1007.6[##] 1004.0	2	0
80	Railmagra	1973[#] 2006	1418.0[##] 915.0	2	0
81	Rajsamand	1973 2010[#]	1001.9 1039.0[##]	2	0
84	Badgaon *	1973[#] 2006	1258.0[##] 1072.0	2	0
85	Bhadesar	1973	1228.9	1	0
86	Badi Sadri	1961 1973[#]	1328.1 1441.4[##]	2	0
87	Bhopalsagar	1973	1332.0	1	0
89	Chittaurgarh	1973[#] 1975	1330.2[##] 1265.5	2	0
90	Dungla	1973	1638.2	1	0
95	Nimbahera	1973[#] 2006	2263.2[##] 1378.0	2	0
98	Sandesar *	1973[#] 1983	1400.0[##] 924.6	2	0
99	Bagolia *	1973[#] 2006	1030.9[##] 975.0	2	0
102	Maoli	1973[#] 2006	1188.7[##] 1165.0	2	0
104	Udaipur Dabok (a)	1973	1383.5	1	0
108	Vallabhnagar	*1969*[###] 1973[#] 2006 2010	*140.0*[####] 1415.8[##] 1163.0 1055.0	3	1
109	Vallabhnagar *	1973 1983[###]	1399.0 2.8[####]	1	1
116	Sawar	2004	957.5	1	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
134	Jawaja	1973 1976#	959.4 968.0##	2	0
140	Arwar Dam *	2004	1147.0	1	0
141	Asind	1976	806.6	1	0
142	Badnore	1976	872.0	1	0
146	Khari Dam *	1968# 1983	898.7## 834.6	2	0
147	Nahar Sagar *	1996 2004#	1147.0 1154.0##	2	0
148	Patan *	1976# 1983	874.0## 749.6	2	0
150	Shahpura	1996 2004#	986.0 1044.0##	2	0
151	Ummed Sagar *	2004	1075.0	1	0
153	Deo Garh	1973 1994#	1294.0 1017.0##	2	0
280	Chhoti Sadri	1961 1973# 2006	1434.1 1622.1## 1617.0	3	0
283	Pratap Garh	1973	1668.7	1	0
298	Babalwara *	1973 1975 1976 1977# 1983	1275.2 2859.0 2723.3 2969.8## 1211.1	5	0
299	Jaisamand *	1973	1715.5	2	0
306	Sarada	1973 1994 2006#	1043.7 973.0 1155.0##	3	0
307	Som Kagdar *	1983# 2006	1290.0## 1205.0	2	0
315	Kotra	1973# 2006	206.8## 1564.0	2	0
321	Jhadol	1973	1475.1	1	0
325	Abu Road	1961 1973# 1977 1994 2006	1208.8 1650.4## 1232.1 1389.6 1286.0	5	0
328	Kadambari *	1973# 1992 2006	4106.0## 2246.0 2452.0	3	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
331	Mount Abu (a)	1973[#] 1994	3245.9[##] 3073.6	2	0
332	Mount Abu	1973	3621.2	1	0
333	Pindwara	1973[#] 1990 1992 2006	2115.6[##] 1351.0 1249.0 1849.0	4	0
336	West Banas *	1973	2868.0	1	0
384	Kumbhalgarh	1973	1537.0	1	0
390	Bhula *	1961[#] 1990 2006	1553.6[##] 1478.7 1468.3	4	0
651	Bharai *	1970 1973[#]	1013.4 1060.0[##]	2	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

[#] - maximum upper outlier year

[##] - value of maximum upper outlier year

[###] - lower outlier year

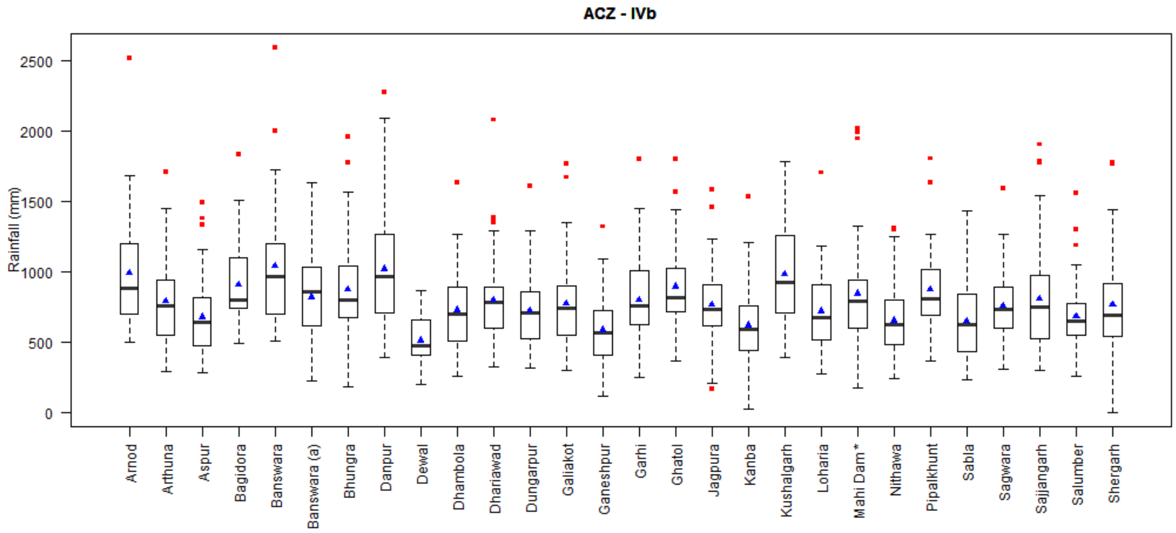
[####] - value of lower outlier year

Source: WRD Daily Rainfall Data (1957-2010)

j. Boxplot Analysis of Annual Rainfall in ACZ IVb

Figure 7.50 depicts Boxplots of 28 stations, based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone IVb.

Figure 7.50 Boxplots of Stations in Agroclimatic Zone IVb, Based on Annual Rainfall Data of 1957 to 2010



It may be observed that there are 4 stations with normal rainfall, as there are no outliers observed (as can be seen from the Figure 7.50). The details of 24 stations with outliers and their respective outlier years of rainfall are tabulated in Table 7.31. It is seen that 1973 and 2006 are mostly observed as outlier years in ACZ IVb, as most of the stations have their extreme rainfall in these years.

Table 7.31 Results of Agroclimatic Zone IVb Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
3	Arnod	2006	2518.0	1	0
264	Arthuna	1973	1705.0	1	0
266	Banswara	1977 2006$^{\#}$	1997.0 2591.0$^{\#\#}$	2	0
267	Bhungra	1973 2006$^{\#}$	1777.2 1958.0$^{\#\#}$	2	0
268	Danpur	1994	2271.0	2	0
269	Garhi	2006	1802.0	1	0
270	Ghatol	1973 2006$^{\#}$	1564.5 1802.0$^{\#\#}$	2	0
271	Jagpura	*1966*$^{\#\#\#}$ 1973$^{\#}$ 2006	*170.2*$^{\#\#\#\#}$ 1581.6$^{\#\#}$ 1461.0	2	1
273	Loharia	2006	1704.0	1	0
274	Mahi Dam *	1973 1977$^{\#}$ 2006	1944.3 2019.0$^{\#\#}$ 1991.0	3	0
275	Pipalkhunt	1973 2006$^{\#}$	1635.0 1804.0$^{\#\#}$	2	0
288	Dhariawad	1973$^{\#}$ 1976 1994	2078.6$^{\#\#}$ 1348.4 1382.4	3	0
290	Aspur	1973 1994 2006$^{\#}$	1335.2 1379.0 1494.0$^{\#\#}$	3	0
294	Dungarpur	2006	1611.0	1	0
295	Ganeshpur	2006	1320.0	1	0
296	Nithawa	1958 1994$^{\#}$	1296.5 1312.0$^{\#\#}$	2	0
305	Salumber	1973$^{\#}$ 1994 2006	1556.5$^{\#\#}$ 1187.0 1299.0	3	0
308	Galiakot	1973$^{\#}$ 2006	1766.6$^{\#\#}$ 1671.0	2	0
309	Sagwara	2006	1588.0	1	0
310	Bagidora	2006	1833.0	1	0
322	Dhambola	2006	1633.0	1	0
323	Kanba	1994	1531.5	1	0

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
820	Sajjangarh	1973 2006$^{\#}$ 2007	1780.8 1904.0$^{\#\#}$ 1771.0	3	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

$^{\#}$ - maximum upper outlier year

$^{\#\#}$ - value of maximum upper outlier year

$^{\#\#\#}$ - lower outlier year

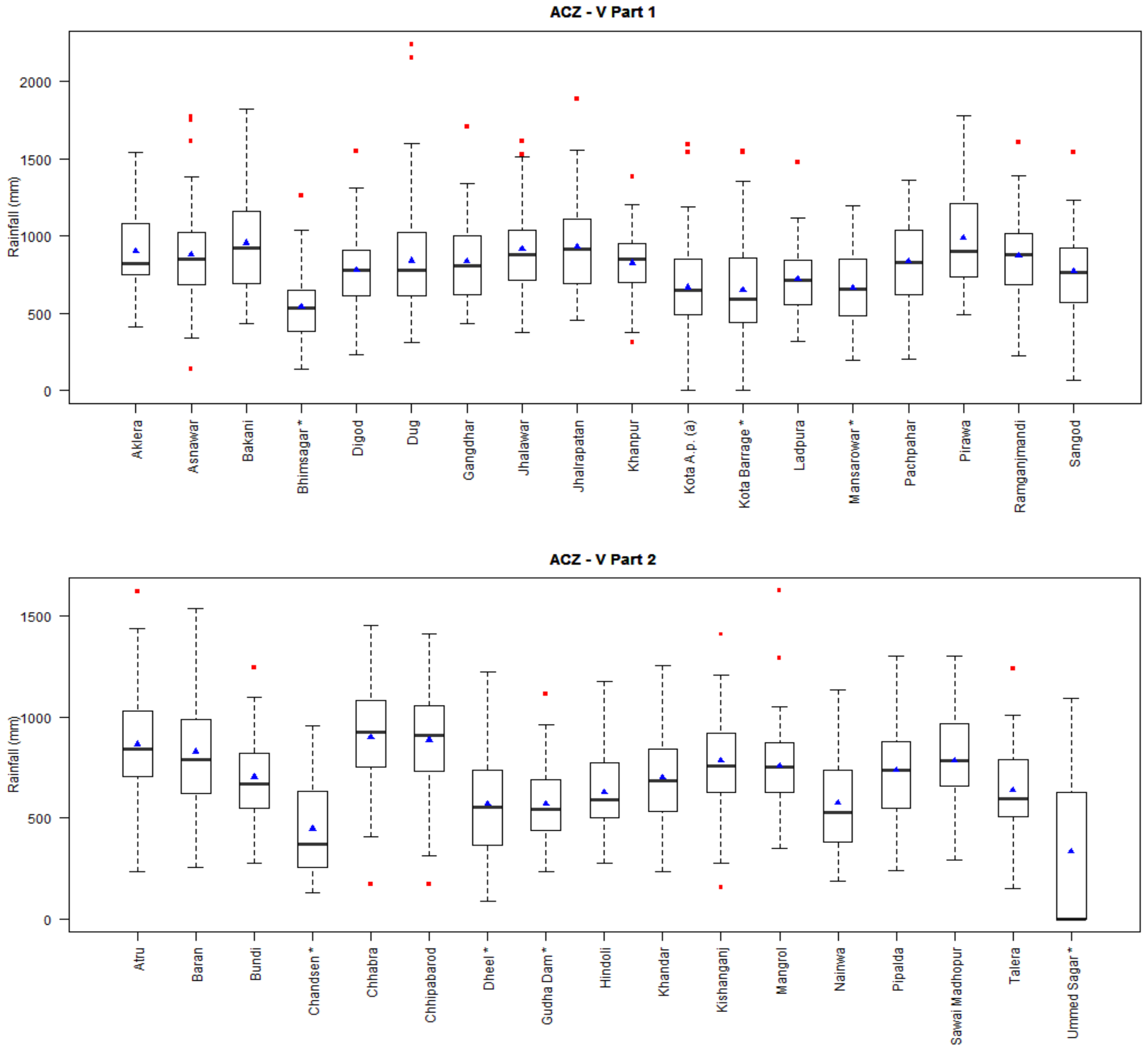
$^{\#\#\#\#}$ - value of lower outlier year

Source: WRD Daily Rainfall Data (1957-2010)

k. Boxplot Analysis of Annual Rainfall in ACZ V

Figure 7.51 depicts Boxplots of 35 stations, based on Rajasthan annual rainfall data of 54 years, from 1957 to 2010 in agroclimatic zone V.

Figure 7.51 Boxplots of Stations of Agroclimatic Zone V, Based on Annual Rainfall Data of 1957-2010



It may be observed that there are 14 stations with normal rainfall as there are no outliers observed (as can be seen from Figure 7.51). The details of 21 stations with outliers and their respective outlier rainfall years are tabulated in Table 7.32. It is seen that 1971 and 1973 are mostly observed as outlier years in ACZ V, as most of the stations have their extreme rainfall in these years.

Table 7.32 Results of Agroclimatic Zone V Annual Rainfall Analysis

Station WRIS code	Station Name	Years of outliers	Annual Rainfall Values of outlier years , mm	Number of upper outliers	Number of lower outliers
12	Digod	1971	3096.0	1	0
15	Kota A.P. (a)	1971# 1986	3180.2## 3081.6	2	0
17	Kota Barrage *	1971# 1986	3097.1## 3085.8	2	0
19	Ladpura	1971	2951.0	1	0
25	Gangdhar	1973	3418.4	1	0
31	Asnawar	1961# 1966 ### 1971 2006	3546.4## 279.2 #### 3501.0 3230.0	3	1
33	Bhimsagar *	2006	2522.0	1	0
34	Dug	1969 1973#	4303.4 4482.6##	2	0
36	Jhalawar	1961 2006#	3056.4 3229.0##	2	0
37	Jhalrapatan	1986	3781.6	1	0
38	Khanpur	1961 2002###	2772.8 623.6####	1	1
45	Ramganjmandi	1996	3216.8	1	0
46	Sangod	1961	3087.8	1	0
48	Bundi	1996	2490.8	1	0
49	Gudha Dam *	1973	2230.6	1	0
52	Talera	1990	2482.0	1	0
59	Atru	1961	3242.0	1	0
61	Chhabra	1989	341.6	0	1
62	Chhipabarod	1965	348.4	0	1
63	Kishanganj	1972### 1975	312.1#### 2819.4	1	1
64	Mangrol	1971 1975#	2579.4 3253.0##	2	0

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations

- maximum upper outlier year

## - value of maximum upper outlier year

### - lower outlier year

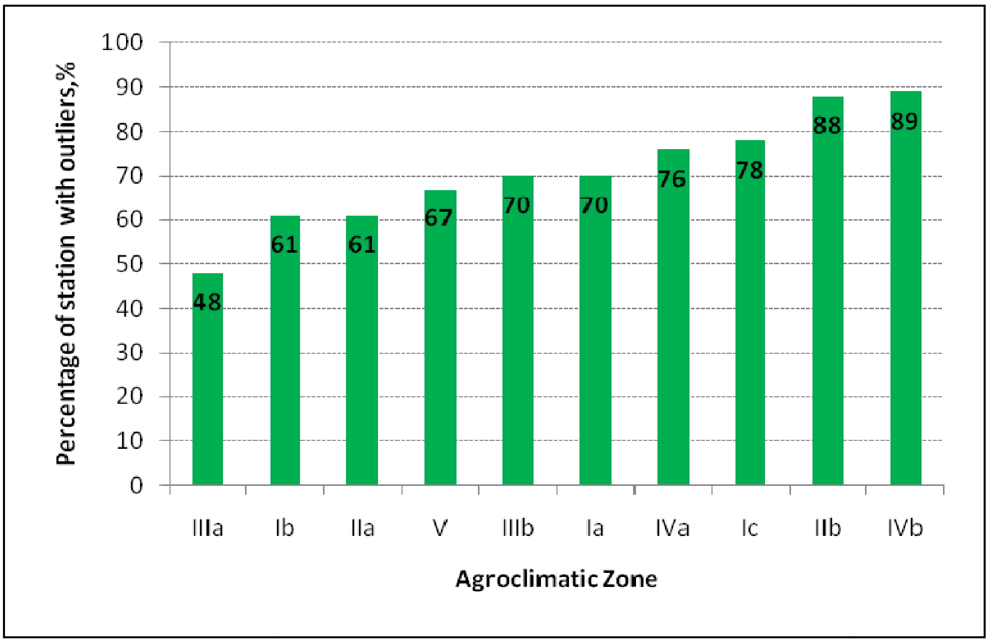
#### - value of lower outlier year

Source: WRD Daily Rainfall Data (1957-2010)

7.11 Conclusions Based on the Agroclimatic Zone-Wise Annual Rainfall Analysis

From the boxplot analyses performed it can be concluded that overall in Rajasthan there are 227 stations (69.6% of the 327 stations selected for analysis) that do not have a normal rainfall pattern since they have observations that can be termed outliers, while 100 stations (30.4%) have normal rainfall with no observation termed outliers. Furthermore, the majority of the outliers belong to the 'upper outlier' category. Station 198 in ACZ IIIb is an exceptional case with as many as 5 'lower outliers'. The maximum number of outliers observed for any given ACZ is 5. Figure 7.52 below gives a summary of the percentage of stations with outliers in all ACZs.

Figure 7.52 Agroclimatic Zone- wise Percentage of Stations with Outliers

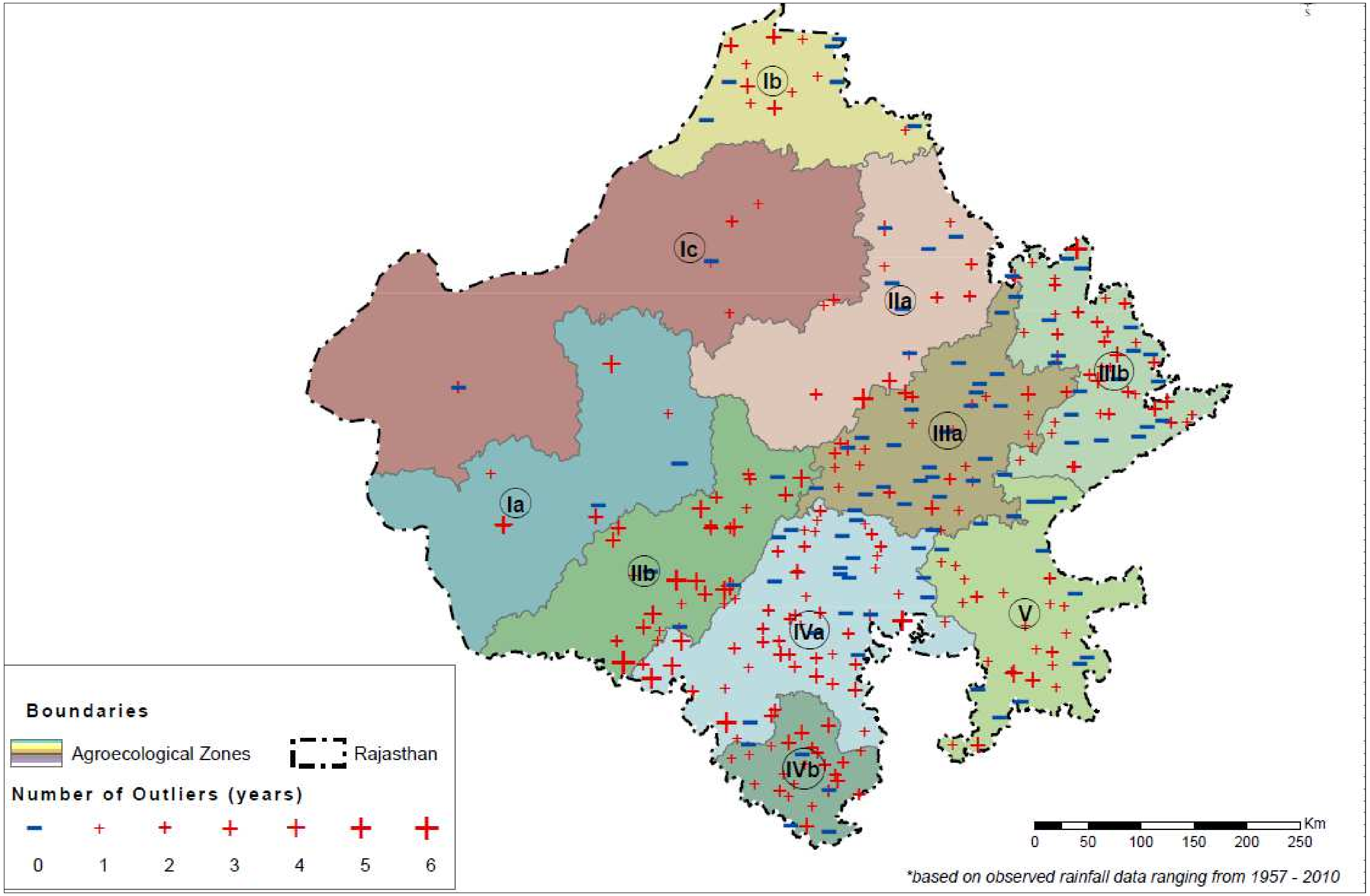


From Figure 7.52 it can be seen that ACZs IVb and IIb have stations with highest percentage of outliers, amounting to 89 and 88% of all stations, respectively. Out of a total of 32 stations in IIb, 28 stations have outliers observed in some or another year, i.e. 88% of its stations have extreme rainfalls observed over the years, while IIIa has the minimum percentage (48%) of stations with outliers.

From Figure 7.53 it can be seen that the eastern region of Rajasthan, i.e. areas of ACZ IIIa, northern region of IVa and Southern region of IIIb have normal rainfall, as there are relatively fewer stations with outliers in these areas, while the southern region, comprised of ACZ IIb and the southern region of ACZs IVa and IVb are areas with outliers (denoted by + in the map) with heavy rainfall, while the negative symbol indicates no outliers.

A larger size of the + symbol in Figure 7.53 indicates a higher number of outliers in that station, and vice-versa.

Figure 7.53 ACZ's Annual Rainfall Analysis of Outliers from 1957 to 2010

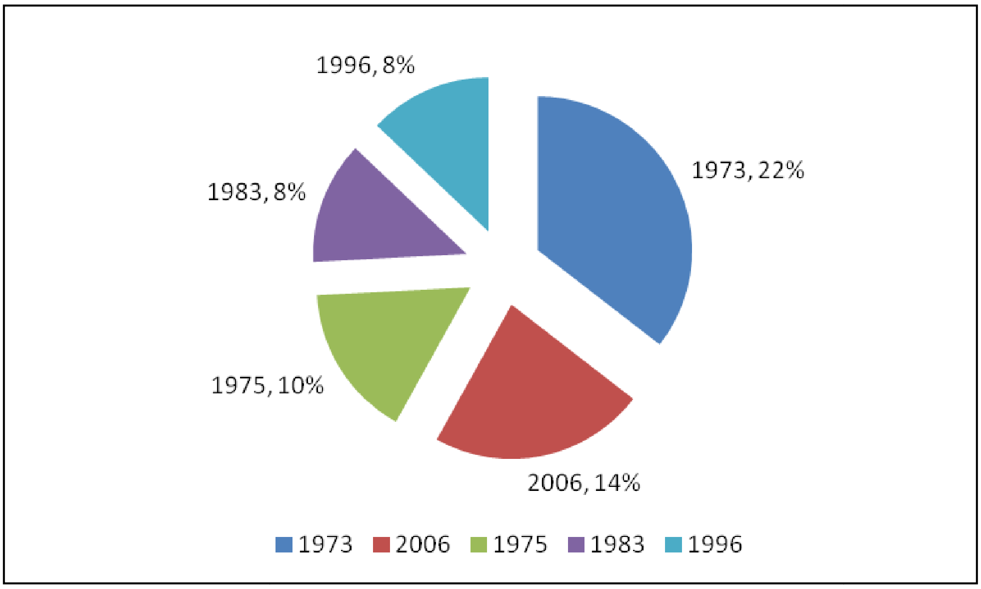


*based on observed rainfall data ranging from 1957 - 2010

Years 1973, 2006, 1975, 1983 and 1996 appear as outlier years with a maximum number of times for the respective stations.

Figure 7.54 summarizes the percentage of stations having outliers in these years.

Figure 7.54 Years with Maximum Number of Outliers as % of Total Outliers



The pie-chart in Figure 7.54 shows that 22% of stations fall in 1973, 14% in 2006 and so on. These are only some of the years with maximum number of outliers but there are many other years in which the stations are termed outlier and have been tabulated in the respective ACZ boxplot tables (refer Table 7.23 to 7.32).

Some of the common rainfall statistics have also been worked out per agroclimatic zone. Table 7.33 below summarizes ACZ-wise rainfall statistics, using daily rainfall data of 54 years (1957 - 2010).

From Table 7.33 it is evident that the highest mean annual rainfall occurs in ACZ IVb (782.8 mm) while it is lowest in ACZ Ib (244.0 mm).

In Cold Weather season (Dec - Jan - Feb.), the highest mean seasonal rainfall falls in ACZ IIIb (17.9 mm) while it is lowest in IIb (3.6).

During the pre-monsoon season (Mar. - Apr. - May) ACZ IIa receives the highest mean seasonal rainfall (29.2 mm) while ACZ IVb shows the lowest mean seasonal rainfall (6.8 mm).

In the monsoon season (Jun. - Jul. - Aug. - Sept.), ACZ IVb shows the highest mean seasonal rainfall (744.8 mm), while the lowest rainfall is observed in ACZ Ib (200.6 mm).

Post-monsoon (Oct. - Nov.) statistics show that ACZ IVb receives the highest mean seasonal rainfall (26.2 mm), while ACZ Ib receives the lowest (4.3 mm).

Table 7.33 Agroclimatic Zone-Wise Rainfall Statistics in Different Seasons (1957-2010)

ACZ	Annual Mean, mm	Inter Annual Variation, CV*	Range of Annual Mean, mm	Range of CV
Annual				
Ia	270.2	0.4	86.4 - 567.4	0.4 - 0.8
Ib	244.0	0.4	110.6 - 459.3	0.4 - 0.9
Ic	281.4	0.3	70.1 - 501.5	0.4 - 0.6
IIa	439.4	0.3	188.6 - 819.2	0.4 - 0.6
IIb	412.2	0.4	108.2 - 1060.0	0.5 - 0.9
IIIa	518.7	0.3	205.9 - 841.8	0.3 - 0.6
IIIb	618.7	0.3	284.6 - 1027.4	0.3 - 0.6
IVa	615.5	0.3	310.7 - 1174.0	0.3 - 1.0
IVb	782.8	0.3	363.1 - 1657.6	0.3 - 0.5
V	773.4	0.2	371.7 - 1254.7	0.3 - 1.1
Cold Weather (December -January - February)				
Ia	5.8	1.2	0.0 - 31.8	1.2 - 3.0
Ib	16.8	0.9	0.0 - 67.7	0.9 - 1.7
Ic	13.5	1.0	0.1 - 64.0	1.1 - 1.6
IIa	17.7	1.0	0.0 - 64.4	0.9 - 1.3
IIb	3.6	1.3	0.0 - 21.8	1.2 - 7.3
IIIa	11.4	1.0	0.1 - 39.2	0.9 - 5.1
IIIb	17.9	0.9	0.0 - 57.0	0.9 - 5.3
IVa	6.6	1.2	0.0 - 30.9	1.2 - 7.0
IVb	4.9	1.8	0.0 - 43.5	1.7 - 5.0
V	11.2	1.3	0.0 - 72.8	1.1 - 6.6
Pre-Monsoon (March-April-May)				
Ia	16.5	1.2	0.3 - 119.6	1.2 - 2.9
Ib	22.4	0.9	1.1 - 91.9	1.0 - 2.1
Ic	26.1	0.9	0.3 - 115.1	1.0 - 1.5
IIa	29.2	0.9	0.3 - 119.9	0.9 - 1.4
IIb	8.4	1.7	0.0 - 76.4	1.3 - 4.4
IIIa	16.7	1.1	0.0 - 96.8	0.9 - 4.3
IIIb	20.0	0.9	0.0 - 89.3	0.9 - 5.2
IVa	12.4	1.1	0.2 - 76.6	1.0 - 6.6
IVb	6.8	1.8	0.0 - 56.0	1.8 - 5.3
V	10.4	1.0	0.0 - 42.4	1.1 - 6.2
Monsoon (June-July-August-September)				
Ia	239.9	0.4	81.0 - 541.9	0.4 - 0.8
Ib	200.6	0.4	52.7 - 398.5	0.5 - 0.9
Ic	233.8	0.4	30.5 - 464.8	0.4 - 0.7
IIa	381.2	0.4	130.9 - 764.4	0.4 - 0.6
IIb	390.9	0.5	96.4 - 1053.5	0.5 - 1.0

ACZ	Annual Mean, mm	Inter Annual Variation, CV*	Range of Annual Mean, mm	Range of CV
IIIa	479.2	0.3	162.3 - 820.2	0.3 - 0.7
IIIb	564.0	0.3	219.6 - 968.4	0.3 - 0.6
IVa	579.3	0.3	289.8 - 1163.0	0.3 - 0.9
IVb	744.8	0.4	315.3 - 1649.6	0.3 - 0.5
V	726.1	0.2	345.8 - 1148.9	0.3 - 0.6
Post Monsoon (October-November)				
Ia	7.9	1.6	0.0 - 52.8	1.8 - 2.8
Ib	4.3	1.7	0.0 - 31.7	2.1 - 5.3
Ic	8.0	2.1	0.0 - 88.9	1.9 - 3.2
IIa	11.3	1.9	0.0 - 129.8	1.4 - 3.1
IIb	9.3	1.6	0.0 - 63.8	1.7 - 5.0
IIIa	11.4	1.6	0.0 - 80.7	1.5 - 5.4
IIIb	16.9	1.2	0.0 - 85.0	1.4 - 5.4
IVa	17.1	1.5	0.0 - 92.9	1.5 - 4.5
IVb	26.2	1.5	0.0 - 155.3	1.2 - 3.0
V	25.7	1.4	0.0 - 143.5	1.3 - 4.8

* CV - Coefficient of Variation

7.12 Agroclimatic Zone-Wise Rainfall Stations Trend Analysis

7.12.1 Analysis

A trend analysis of the rainfall data was performed using the Mann Kendall method. To start with, 327 observed stations in Rajasthan, which had more than 30 years of data have been analyzed for temporal variation in seasonal and annual rainfall (see Table 7.34).

A series is considered showing statistically significant trend when its Confidence level is greater than 90%.

ACZ-wise seasonal and annual trends of rainfall are shown in Table 7.34. It may be observed from the table that the maximum percentage of stations showing a statistically significant negative trend are in ACZ IIIb for both annual and monsoon months, while the maximum percentage of stations showing statistically a significant positive trend are in ACZ Ia and Ic for monsoon months and Ia for the annual data.

Table 7.34 Trend Summary of rainfall for Various Agroclimatic Zones using Monsoon (June-July-August-September - JJAS) and Annual data

ACZ	No of Stations	No. of Stations with Negative Trend #	No. of Stations with Positive Trend #	% of Stations with Significant* Negative Trend	% of Stations with Significant* Positive Trend
Monsoon Months (JJAS)					
Ia	10	3(1)	7(2)	10	20
Ib	18	11(2)	7(1)	11	6
Ic	9	2(0)	7(2)	0	22
IIa	18	14(0)	4(0)	0	0
IIb	30	15(1)	15(0)	3	0
IIIa	50	30(6)	20(6)	12	12
IIIb	55	45(11)	10(1)	20	2
IVa	73	29(1)	44(6)	1	8
IVb	29	9(0)	20(5)	0	17
V	35	31(6)	4(1)	17	3
Annual					
Ia	10	3(1)	7(2)	10	20
Ib	18	8(0)	10(1)	0	6
Ic	9	1(0)	8(1)	0	11
IIa	18	5(0)	13(0)	0	0
IIb	30	11(1)	19(0)	3	0
IIIa	50	25(7)	25(5)	14	10
IIIb	55	40(8)	15(2)	15	4
IVa	73	25(3)	48(5)	4	7
IVb	29	9(1)	20(1)	3	3
V	35	29(6)	6(1)	17	3

# Figures in brackets indicate number of stations with significant trend.
* Significant Trend - A trend is considered here as Statistically significant when its Confidence level is greater than 90%.

Source: WRD Daily Rainfall Data (1957-2010)

Table 7.35 Trend Analysis of Rainfall in Monsoon Months within Various Agroclimatic Zones

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
June	1957	10.4	13.1	37.2	43.8	55.2	39.7	56.0	64.6	89.0	57.9
	1958	7.1	0.9	22.6	33.6	24.5	37.9	19.8	51.3	41.4	57.6
	1959	31.3	35.8	26.1	40.2	39.0	43.3	14.1	77.9	92.0	83.2
	1960	31.3	35.8	26.1	40.2	39.0	43.3	14.1	77.9	92.0	83.2
	1961	122.1	37.6	79.0	39.1	65.6	31.1	30.4	47.6	51.2	21.0
	1962	0.7	0.9	1.6	2.2	7.9	0.2	9.5	4.8	7.4	2.1
	1963	4.4	2.7	7.9	31.3	16.4	20.5	18.7	25.3	41.5	35.3
	1964	16.1	3.3	25.4	6.4	35.8	8.2	9.8	62.7	49.5	60.6
	1965	1.0	1.7	12.4	13.0	0.3	5.3	2.0	5.2	0.8	10.6
	1966	20.5	28.2	26.8	47.2	46.3	68.1	61.8	64.3	46.1	90.1
	1967	28.0	30.2	24.6	48.7	58.3	67.6	33.8	95.1	150.2	101.5
	1968	0.0	1.2	0.0	3.8	0.0	1.7	6.8	7.3	2.4	7.0
	1969	1.5	6.4	0.6	11.5	4.1	13.9	6.8	16.4	57.5	14.4
	1970	29.8	21.1	23.4	49.5	56.5	50.8	54.6	122.9	180.9	95.2
	1971	61.1	17.4	72.1	164.1	85.1	254.1	129.8	103.4	169.7	210.4
	1972	19.7	10.8	59.9	48.5	59.1	74.1	27.0	101.2	107.7	55.3
	1973	35.5	0.1	2.3	6.5	47.5	18.4	14.2	46.4	81.6	36.5
	1974	24.8	31.4	27.0	38.7	21.4	36.4	15.2	37.0	33.9	22.9
	1975	65.0	42.1	41.8	44.7	65.0	50.4	38.7	119.2	141.5	109.6
	1976	6.6	85.2	62.7	116.6	22.0	55.4	110.4	43.7	110.4	152.3
	1977	83.4	104.1	108.1	137.8	117.2	113.0	88.6	107.3	214.4	104.9
	1978	28.8	13.3	23.4	52.1	39.6	90.2	61.6	63.2	59.7	118.4
	1979	43.1	6.0	4.9	17.5	40.0	35.2	38.7	53.8	77.0	51.6

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
June	1980	40.1	18.6	32.2	61.3	104.7	105.1	98.0	186.8	257.4	135.4
	1981	29.3	2.2	14.6	20.6	33.0	39.8	65.3	61.6	122.6	49.5
	1982	11.7	27.2	26.3	27.3	12.5	21.2	30.7	31.8	54.0	20.0
	1983	28.3	13.7	44.9	49.8	100.3	32.6	46.3	106.5	107.7	61.3
	1984	2.0	8.3	3.2	14.8	25.3	22.5	29.7	35.3	15.4	52.9
	1985	0.5	46.7	8.6	42.2	18.5	9.1	29.5	13.4	4.3	16.7
	1986	2.3	59.2	41.3	36.1	7.7	30.7	52.7	40.3	56.5	89.4
	1987	28.9	16.9	59.4	19.6	36.0	38.8	16.4	58.5	78.1	40.0
	1988	17.3	12.6	39.6	87.8	45.8	56.4	83.9	79.7	51.0	156.0
	1989	18.4	42.4	17.2	30.6	36.2	34.9	32.5	73.5	116.3	84.4
	1990	19.6	15.9	6.8	34.0	24.2	58.0	28.9	72.8	132.2	95.0
	1991	7.8	45.7	25.0	20.6	9.1	12.0	11.2	15.8	25.8	11.9
	1992	2.9	3.7	15.3	15.3	11.7	4.9	16.2	16.1	28.5	12.6
	1993	25.1	41.4	64.2	77.1	56.9	99.9	52.5	92.0	127.9	138.3
	1994	15.8	0.7	32.5	64.0	40.2	74.2	50.6	136.9	237.9	139.4
	1995	12.0	20.7	21.5	43.3	10.0	10.5	31.1	14.6	38.6	7.8
	1996	163.1	70.4	189.0	301.3	82.9	135.9	276.5	68.0	53.2	30.8
	1997	77.3	23.5	97.6	67.6	75.4	68.2	67.7	66.0	121.4	89.0
	1998	133.3	21.1	69.4	69.6	50.8	33.9	58.4	58.5	68.2	83.5
	1999	47.0	43.0	30.5	49.1	45.5	56.6	50.5	89.5	173.0	81.9
	2000	8.3	1.3	19.3	18.0	17.0	10.5	41.6	15.0	42.3	19.8
	2001	52.5	69.1	70.4	100.5	71.2	79.3	122.4	101.6	140.7	131.7
	2002	53.2	20.0	7.7	48.6	76.9	43.7	32.8	84.8	160.8	88.8
	2003	44.3	24.3	12.8	55.6	89.9	58.9	47.0	79.6	123.1	94.5

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
June	2004	25.3	70.5	22.1	15.6	43.5	26.4	36.9	45.5	101.8	70.3
	2005	23.5	28.2	33.0	86.3	27.0	71.2	68.9	48.0	63.1	69.9
	2006	31.5	62.5	50.0	47.2	48.7	56.8	63.2	96.0	156.2	100.5
	2007	17.5	138.9	31.0	49.1	33.7	56.7	85.3	41.3	70.5	123.6
	2008	56.9	91.2	54.8	155.9	35.6	150.0	276.5	110.5	84.2	212.1
	2009	18.9	14.9	41.1	49.1	20.4	27.0	28.2	51.3	53.5	34.7
	2010	36.0	31.3	100.0	49.9	7.9	10.5	24.2	32.4	24.8	32.4
Positive (P) or Negative (N) trend		P	P	P	P	P	P	P	P	P	P
Confidence Level, %		$81^{\#}$	94	92	99	$20^{\#}$	$70^{\#}$	100	$38^{\#}$	$75^{\#}$	$70^{\#}$
July	1957	39.1	63.5	118.9	227.0	75.3	254.4	241.0	157.9	121.3	380.2
	1958	61.8	58.5	56.2	126.4	113.6	191.2	356.3	256.8	252.9	411.3
	1959	96.0	123.7	96.0	105.2	142.5	80.6	134.4	149.2	233.7	192.9
	1960	96.0	123.7	96.0	105.2	142.5	80.6	134.4	149.2	233.7	192.9
	1961	67.9	39.1	66.1	133.6	159.6	164.0	227.4	174.9	262.3	300.6
	1962	105.9	63.0	114.3	261.5	224.5	229.2	207.6	212.7	318.5	353.2
	1963	21.6	30.1	20.4	46.5	41.4	81.6	90.7	133.4	222.9	173.5
	1964	123.6	160.2	149.0	217.4	65.5	147.8	286.2	168.5	200.7	194.0
	1965	166.8	62.2	100.5	113.4	296.3	155.2	162.7	258.1	227.3	233.5
	1966	53.6	46.8	42.8	94.1	96.0	93.6	100.1	159.9	137.0	188.7
	1967	90.3	31.4	32.9	76.8	152.4	124.8	197.1	146.4	166.1	127.5
	1968	78.3	72.3	81.2	334.6	121.6	241.6	290.2	236.3	366.7	307.4
	1969	22.0	40.0	88.9	97.4	63.2	159.4	213.6	184.8	263.7	315.3
	1970	70.3	41.7	56.6	100.2	92.5	134.7	87.0	142.4	132.4	199.3

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
July	1971	74.6	35.7	47.3	133.4	167.7	234.2	231.9	227.0	232.1	480.4
	1972	27.1	65.8	13.9	37.9	64.2	54.6	115.7	87.1	156.0	78.5
	1973	60.0	51.5	55.4	127.9	104.1	176.8	145.9	278.0	324.8	423.1
	1974	68.5	96.9	153.7	288.1	43.8	338.5	322.5	180.8	200.3	436.1
	1975	172.1	101.7	165.1	312.5	254.4	326.2	309.7	206.3	189.8	243.0
	1976	102.9	55.5	79.2	143.1	137.7	199.9	213.8	232.9	243.9	201.3
	1977	113.3	110.9	132.8	309.1	300.7	380.1	437.2	292.1	379.7	338.8
	1978	156.3	303.9	249.2	427.2	240.4	274.3	220.8	277.3	377.1	290.7
	1979	117.4	19.6	40.7	121.0	403.3	268.7	152.7	223.8	130.4	262.4
	1980	117.0	138.9	102.7	219.1	217.2	197.6	264.0	180.9	166.2	168.2
	1981	50.1	145.7	147.0	238.1	89.2	486.8	336.8	157.1	249.8	295.0
	1982	90.1	48.9	71.0	79.5	129.6	125.9	179.4	176.3	225.2	256.1
	1983	133.4	181.2	153.4	229.9	298.9	315.8	275.5	245.9	275.1	191.1
	1984	39.5	65.5	49.0	71.8	82.6	97.3	167.0	177.3	261.8	118.7
	1985	88.9	153.2	73.5	168.3	96.6	164.0	269.2	127.2	100.7	153.9
	1986	63.1	91.7	87.7	119.5	130.3	188.4	119.6	302.5	469.6	608.7
	1987	35.6	26.3	11.0	35.0	26.2	42.1	54.7	49.0	30.1	95.8
	1988	104.6	105.6	84.5	166.2	176.4	183.9	251.9	222.9	257.9	248.0
	1989	53.1	66.8	116.8	94.0	56.4	103.5	101.4	172.8	165.6	109.1
	1990	264.0	91.7	78.9	118.4	265.2	181.8	161.5	228.9	322.1	216.1
	1991	70.8	11.0	42.3	107.8	107.5	178.7	86.8	352.4	523.9	340.8
	1992	89.1	108.3	149.5	146.9	247.3	205.4	191.4	289.2	233.5	197.3
	1993	173.6	94.9	115.9	221.8	232.0	194.8	215.9	266.7	511.8	210.8
	1994	168.9	82.2	152.7	214.8	189.3	294.3	300.8	321.2	348.5	371.9

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
July	1995	248.9	59.2	177.9	178.8	246.5	283.4	195.4	296.0	319.0	282.4
	1996	48.0	18.7	61.4	98.3	109.9	204.7	188.0	306.2	390.2	315.5
	1997	49.0	36.6	87.0	123.2	106.1	166.3	135.2	175.4	291.8	244.2
	1998	28.8	86.1	98.9	130.7	59.6	256.4	194.3	132.4	253.4	208.5
	1999	51.5	44.0	86.9	108.2	122.7	205.6	170.0	227.2	236.7	438.5
	2000	166.4	123.1	196.1	167.8	237.7	224.3	201.5	257.3	237.6	432.7
	2001	152.6	114.2	85.5	157.7	257.4	236.5	231.8	355.7	290.1	458.4
	2002	0.0	3.3	0.3	9.7	2.6	14.7	26.3	12.4	11.3	21.0
	2003	240.3	91.1	181.6	225.3	256.7	234.2	317.0	219.8	319.1	193.8
	2004	27.3	21.6	3.2	56.4	64.2	77.3	57.7	155.7	141.8	142.2
	2005	86.0	47.3	123.8	143.0	117.0	175.2	364.6	199.1	288.7	350.8
	2006	20.7	126.6	56.8	148.5	129.0	146.9	209.1	220.1	419.5	237.2
	2007	65.7	68.1	61.4	82.5	305.3	128.3	108.6	327.9	456.6	259.6
	2008	81.3	59.1	38.8	68.1	59.4	132.8	206.2	153.3	203.9	214.2
	2009	96.5	70.2	109.4	80.3	157.9	133.2	135.7	259.1	351.1	275.1
	2010	117.6	100.4	120.3	159.8	167.3	173.8	191.4	215.7	178.9	187.1
Positive(P) or Negative(N) trend		P	P	P	N	P	P	N	P	P	N
Confidence Level, %		25[#]	13[#]	37[#]	62[#]	54[#]	39[#]	54[#]	93	92	17[#]
August	1957	122.1	43.0	62.0	111.1	206.6	221.5	149.0	264.5	204.3	286.5
	1958	12.6	13.5	20.9	60.8	25.2	116.9	215.0	123.4	185.0	192.5
	1959	57.2	86.6	55.8	157.2	141.5	274.2	439.8	244.5	197.2	459.0
	1960	57.2	86.6	55.8	157.2	141.5	274.2	439.8	244.5	197.2	459.0
	1961	49.1	70.4	84.0	144.6	97.2	204.1	347.0	179.8	135.4	260.8

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
August	1962	46.4	35.2	48.2	120.3	73.1	131.1	157.0	167.8	185.4	253.0
	1963	82.7	116.0	90.5	204.9	147.2	228.0	306.2	246.7	326.8	363.1
	1964	115.8	89.5	138.5	268.7	241.2	305.3	290.1	247.4	175.9	286.7
	1965	51.7	36.7	21.6	67.5	91.9	94.4	136.7	109.4	140.5	85.6
	1966	124.9	51.8	110.9	114.3	84.1	144.3	240.1	128.4	79.1	203.1
	1967	66.1	97.9	118.9	158.7	146.2	231.7	423.3	158.4	173.5	342.5
	1968	11.2	28.6	15.2	48.6	96.7	103.7	137.8	229.1	313.7	244.0
	1969	49.6	30.5	38.6	79.2	28.7	93.1	164.7	175.0	252.8	461.3
	1970	175.5	109.2	117.9	282.9	341.7	281.4	263.9	363.7	256.6	306.7
	1971	42.4	61.9	50.8	124.7	59.1	93.0	193.0	118.4	212.2	203.2
	1972	141.6	96.8	89.9	139.1	182.1	193.9	421.0	204.0	257.7	316.7
	1973	294.8	139.4	201.1	233.2	566.7	348.4	269.2	472.0	468.9	368.6
	1974	11.3	18.9	7.7	47.3	59.5	90.9	102.2	189.4	218.0	268.5
	1975	119.7	118.3	118.9	252.2	174.6	270.3	330.4	251.3	337.4	453.4
	1976	149.3	167.6	106.4	226.1	278.3	285.5	341.8	358.9	492.6	272.9
	1977	35.0	30.7	13.1	170.3	100.4	165.4	179.5	196.3	297.0	248.6
	1978	76.9	55.1	61.2	116.9	135.8	157.7	223.7	233.9	503.1	322.8
	1979	112.4	43.0	41.9	41.0	137.5	85.9	54.9	163.2	272.4	155.8
	1980	6.9	22.5	31.6	51.9	51.9	116.5	172.9	109.4	218.3	239.9
	1981	56.2	10.0	46.6	47.1	57.6	78.6	127.0	139.3	335.1	170.7
	1982	52.7	151.8	120.3	125.9	114.3	235.9	335.7	280.6	221.6	472.5
	1983	68.2	106.9	107.2	128.3	166.3	219.0	257.0	266.3	245.3	280.4
	1984	64.4	118.0	71.8	86.6	169.1	155.5	202.9	297.7	665.7	378.9
	1985	40.7	49.9	30.8	107.4	117.2	180.3	173.9	248.2	193.7	360.5

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
August	1986	34.5	34.5	44.9	69.8	53.4	74.7	89.7	162.9	193.9	244.8
	1987	16.8	27.7	41.2	73.2	32.5	130.9	137.2	219.0	563.2	396.4
	1988	63.0	45.6	60.1	129.3	91.0	135.3	166.8	186.6	399.0	218.9
	1989	125.0	28.8	77.5	98.4	144.8	245.7	172.2	371.4	316.7	256.5
	1990	219.5	41.3	90.1	62.4	259.5	168.4	130.0	351.6	379.4	231.9
	1991	56.4	16.4	29.3	139.4	70.2	193.6	217.8	189.0	186.8	333.5
	1992	91.3	121.2	116.3	188.3	191.1	255.5	283.2	230.0	188.9	277.3
	1993	2.5	0.2	7.6	52.1	7.3	86.4	93.5	59.9	87.2	164.9
	1994	127.9	10.2	43.5	96.9	197.4	166.7	159.3	265.6	481.4	321.9
	1995	59.6	67.6	119.2	291.9	83.5	333.1	554.0	117.7	154.0	336.8
	1996	81.8	39.5	69.3	204.7	116.5	304.3	352.8	276.2	337.4	500.2
	1997	150.2	43.0	113.3	169.7	230.5	213.0	225.3	241.3	331.3	318.5
	1998	57.4	22.5	38.2	76.2	45.2	129.2	222.5	116.5	167.6	175.3
	1999	98.5	9.1	75.5	52.1	81.4	64.1	132.2	61.4	69.4	126.9
	2000	55.5	13.2	37.7	71.4	47.0	96.8	126.5	81.1	113.4	113.9
	2001	77.4	43.6	81.7	90.2	141.9	90.9	92.1	148.4	173.8	199.6
	2002	8.8	11.0	12.3	58.5	43.9	82.8	120.8	149.2	169.7	189.5
	2003	77.0	91.2	71.5	135.5	145.6	160.1	227.9	170.0	186.6	235.3
	2004	100.8	95.9	87.9	173.2	181.4	326.1	317.5	457.5	633.7	513.0
	2005	31.5	5.9	3.3	6.8	78.9	38.5	66.4	127.4	127.9	64.0
	2006	288.5	55.3	103.6	45.1	416.9	112.2	52.3	551.8	808.7	415.8
	2007	61.3	64.3	81.2	78.4	77.4	140.6	133.0	160.9	362.1	179.7
	2008	106.7	120.7	104.3	198.0	161.8	153.4	177.3	171.4	159.5	165.4
	2009	24.0	51.3	30.3	52.6	47.4	83.2	165.6	125.8	232.1	138.0

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
August	2010	151.8	130.3	141.0	311.7	190.8	314.6	234.1	307.3	284.9	238.8
Positive (P) or Negative (N) trend		P	N	P	N	N	N	N	N	P	N
Confidence Level, %		48[#]	67[#]	1[#]	77[#]	30[#]	88[#]	97	38[#]	39[#]	95
September	1957	0.5	4.0	2.0	44.4	24.1	53.5	188.9	27.5	15.9	87.7
	1958	101.7	185.2	179.5	193.7	169.0	146.4	239.2	211.6	356.3	237.2
	1959	1.3	4.3	3.5	9.4	6.7	15.1	16.7	20.3	26.0	31.3
	1960	1.3	4.3	3.5	9.4	6.7	15.1	16.7	20.3	26.0	31.3
	1961	104.3	24.5	87.0	69.3	329.8	214.6	111.5	425.6	496.5	566.5
	1962	35.2	72.2	71.3	80.6	34.3	85.3	114.1	123.2	225.6	223.4
	1963	36.5	35.1	4.2	55.0	63.8	64.0	152.6	73.0	185.7	86.3
	1964	5.3	7.1	3.2	64.6	18.5	45.4	102.4	61.7	79.8	87.2
	1965	6.4	5.5	8.0	21.7	5.8	41.1	196.4	57.5	49.6	115.6
	1966	32.1	111.5	53.7	65.3	107.0	75.0	55.5	125.4	98.3	48.0
	1967	72.9	20.4	59.2	66.6	192.8	96.6	142.5	169.3	161.9	224.1
	1968	1.1	0.0	0.0	0.2	1.7	0.9	1.6	11.8	29.7	13.4
	1969	7.9	24.5	12.6	91.1	12.2	85.2	166.1	73.6	120.9	104.9
	1970	60.5	45.0	78.6	93.2	88.8	60.1	111.7	90.0	176.5	133.8
	1971	18.0	20.2	23.7	40.7	23.6	96.3	112.6	84.8	130.3	232.4
	1972	0.6	11.9	2.5	2.3	3.0	2.9	35.1	23.4	20.0	45.0
	1973	41.2	2.8	22.9	37.9	335.2	83.5	88.3	366.6	567.8	220.1
	1974	8.5	0.6	8.9	5.9	16.1	5.7	19.8	19.0	23.2	26.6
	1975	154.0	46.4	113.2	142.5	196.9	173.4	139.0	173.6	260.0	202.0
	1976	123.0	90.3	81.4	58.0	113.6	115.2	69.0	155.1	132.7	157.8

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
September	1977	17.8	28.8	162.9	147.2	12.2	70.4	142.5	85.5	243.0	125.7
	1978	25.4	13.5	20.9	39.1	28.2	44.7	111.4	29.5	43.2	36.5
	1979	5.2	35.7	27.9	12.4	13.8	7.6	11.9	21.5	15.9	8.5
	1980	12.0	17.5	19.9	14.7	20.3	18.8	16.0	40.1	46.6	30.7
	1981	32.2	17.3	11.5	14.6	37.3	46.0	19.7	98.5	109.0	73.1
	1982	5.7	14.3	8.8	9.7	19.8	18.9	17.9	19.1	28.7	26.3
	1983	51.5	61.5	44.7	80.6	49.2	100.7	137.1	118.8	100.5	194.1
	1984	61.6	52.5	50.4	90.5	64.9	97.6	122.7	84.3	66.6	136.7
	1985	2.6	5.0	4.4	14.7	5.5	17.0	31.5	33.3	16.6	79.6
	1986	0.0	7.5	10.6	17.4	0.8	17.6	38.1	8.5	2.2	17.4
	1987	5.4	2.3	2.9	3.1	1.7	17.8	44.0	4.8	3.3	65.6
	1988	20.3	64.1	42.6	102.2	52.3	57.2	56.3	85.8	79.3	60.6
	1989	15.3	2.5	30.7	11.5	29.7	14.5	37.8	42.0	66.4	30.5
	1990	38.8	22.1	38.5	46.1	64.7	89.3	229.5	131.7	204.5	176.2
	1991	5.2	7.1	14.6	26.7	23.7	61.6	52.5	39.1	17.3	34.7
	1992	180.1	58.8	89.3	87.3	245.3	108.9	96.0	159.2	154.0	71.1
	1993	43.5	28.3	50.8	72.6	62.2	70.3	168.1	55.5	79.6	216.9
	1994	72.4	35.2	41.4	34.9	75.8	61.4	30.1	136.1	261.3	113.2
	1995	7.3	0.0	15.1	52.1	21.2	65.9	180.0	52.9	90.6	125.7
	1996	7.6	0.0	11.1	74.4	34.2	139.7	151.2	117.8	186.1	127.2
	1997	18.6	4.2	7.6	43.5	59.0	88.0	122.2	110.2	95.5	87.2
	1998	66.6	83.6	37.4	88.2	58.6	128.7	151.9	148.9	270.2	158.2
	1999	5.8	2.8	9.7	26.3	19.3	57.3	140.0	52.7	84.3	164.5
	2000	1.1	7.4	7.7	25.7	10.8	27.4	26.0	17.8	18.4	46.5

Monsoon Month	ACZ →	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
	Year ↓	Rainfall, mm									
September	2001	1.3	1.6	4.1	2.9	2.3	7.1	15.0	8.6	1.4	3.4
	2002	37.3	18.5	10.2	18.3	44.3	21.1	39.8	43.4	120.3	46.6
	2003	3.7	38.3	15.3	38.3	18.1	79.0	110.7	86.0	118.1	154.3
	2004	9.9	4.0	9.2	9.9	15.9	16.4	27.4	39.2	35.9	21.1
	2005	40.3	67.2	73.8	101.8	153.7	153.7	87.5	259.9	217.8	129.2
	2006	29.0	22.3	22.3	20.4	73.3	40.2	38.8	95.0	265.1	155.3
	2007	35.2	46.4	37.8	94.7	40.6	70.7	99.8	64.5	139.7	108.3
	2008	5.8	48.0	24.8	79.8	45.7	96.5	148.9	102.7	83.9	123.4
	2009	1.7	32.6	7.5	16.3	5.6	34.6	103.2	25.0	97.3	71.9
	2010	86.3	92.6	103.5	164.0	89.8	135.8	217.4	97.8	109.3	115.7
Positive(P) or Negative(N) trend		P	P	P	P	P	P	N	N	N	N
Confidence Level, %		2#	32#	16#	10#	5#	36#	14#	11#	7#	45#

Source: WRD Daily Rainfall Data (1957-2010)

# indicates insignificant (NS) trend as the confidence level is less than 90%.

The rainfall data from 1957 to 2010 have been used to find rainfall trends in the monsoon months within various agro-climatic zones. The results are presented in Table 7.35.

The following points summarize Table 7.35.

- In June, all agroclimatic zones show an increasing trend. However, in Ⅰb, Ⅰc, Ⅱa and Ⅲb the trends are significant, with a confidence level > 90%, while trends in the rest of zones are statistically insignificant.
- In July, only Zones Ⅳa and Ⅳb the increasing trends are statistically significant, with confidence levels >90%. The rest of the zones show statistically insignificant trends.
- In August, Zones Ⅲb and Ⅴ the decreasing trends are statistically significant while the trends in the rest of the zones are statistically insignificant.
- In September, none of the Zones show any significant trend.

Table 7.36 shows monsoon months and annual rainfall trends at various raingauge stations. P signifies a positive or increasing trend while N signifies negative or decreasing trend, calculated using the Mann Kendall test and these are presented in this table along with the confidence levels for each of the ACZs. Only those zones are considered significant for which the confidence level is greater than 90%. # for confidence level signifies ACZs have insignificant trend.

Mann-Kendall trend statistics for 327 rainfall stations have been worked out and are shown in Table 7.36 for annual and monsoon months (June, July, August and September - JJAS).

The table also shows the confidence level with which one can draw an inference for a particular station if it is showing a statistically significant trend denoted by S and insignificant trend denoted by NS with respect to rainfall. (Here Positive, P, Trend signifies increasing trend and Negative, N, trend signifies decreasing trend)

Table 7.36 Monsoon months (June-July-August-September - JJAS) and Annual Rainfall trends using Mann-Kendall Statistic for 327 Rain Gauge Stations

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
ACZ Ⅰa					
350	Pachpadra	P	100, S	P	100, S
354	Balotra	P	95, S	P	91, S
438	Barmer (a)	P	0, NS	N	37, NS
439	Barmer	P	54, NS	P	69, NS
443	Sheo	P	80, NS	P	89, NS
518	Jodhpur	P	78, NS	P	62, NS
520	Jodhpur *	N	22, NS	P	6, NS
523	Phalodi (a)	N	68, NS	N	75, NS
524	Phalodi	N	97, S	N	90, S
536	Osian	P	34, NS	P	66, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
ACZ Ib					
458	Anupgarh	P	28, NS	N	13, NS
460	Bhadra	N	12, NS	P	40, NS
466	Dabla	P	73, NS	P	71, NS
467	Dhaban *	N	51, NS	N	36, NS
470	Ganganagar (a)	P	8, NS	N	58, NS
471	Ganganagar	P	64, NS	P	72, NS
475	Hanumangarh	N	33, NS	P	15, NS
481	Srikaranpur	N	12, NS	P	1, NS
484	Longwala *	P	17, NS	P	15, NS
490	Padampur	N	61, NS	N	37, NS
492	Pilibanga	N	91, S	N	64, NS
495	Raisinghnagar	N	55, NS	N	64, NS
496	Sadulshahar	P	92, S	P	94, S
497	Sangriya	N	42, NS	N	10, NS
502	Suratgarh	P	34, NS	P	64, NS
504	Sunderpura *	N	23, NS	P	1, NS
507	T.A. Singh *	N	91, S	N	72, NS
508	Tibbi	N	35, NS	P	19, NS
ACZ Ic					
444	Bikaner (a)	N	32, NS	N	60, NS
445	Bikaner	P	18, NS	P	78, NS
446	Lunkaransar	P	33, NS	P	59, NS
447	Kolayat	P	93 ,S	P	95, S
449	Nokha	P	38, NS	P	41, NS
456	Sujangarh	N	61, NS	P	16, NS
510	Jaisalmer (a)	P	96, S	P	86, NS
511	Jaisalmer	P	51, NS	P	71, NS
526	Surpura *	P	64, NS	P	65, NS
ACZ IIa					
339	Degana	P	32, NS	P	58, NS
420	Khetri	N	21, NS	P	18, NS
421	Neem Ka Thana	N	15, NS	P	29, NS
422	Udaipur Wati	N	38, NS	P	15, NS
430	Nawa	N	64, NS	N	45, NS
431	Parbatsar	N	87, NS	N	53, NS
432	Dantaramgarh	N	51, NS	P	1, NS
433	Ramgarh Shethan	N	61, NS	P	9, NS
435	Chirawa	N	17, NS	P	43, NS
436	Jhunjhunu	N	61, NS	N	45, NS
437	Pilani (a)	N	14, NS	N	65, NS
450	Churu (a)	P	22, NS	N	4, NS
451	Churu	P	21, NS	P	67, NS
529	Ladnu	N	33, NS	P	29, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
532	Fatehpur	N	17, NS	P	24, NS
533	Laxmangarh	N	50, NS	P	1, NS
534	Sikar *	P	41, NS	P	37, NS
535	Sikar	N	8, NS	P	29, NS
ACZ IIb					
341	Girinanda *	P	50, NS	P	44, NS
348	Jaitaran	P	78, NS	P	88, NS
349	Meli Tank *	N	86, NS	N	88, NS
351	Siwana	P	32,NS	P	37, NS
353	Jaswant Sagar *	P	6, NS	P	12, NS
355	Bilara	N	20, NS	P	30, NS
359	Raipur	P	77, NS	P	1, NS
360	Raipur Luni *	P	79, NS	P	80, NS
361	Sardar Samand *	N	50, NS	N	26, NS
362	Sojat	P	43, NS	P	65, NS
363	Baniawas *	N	22, NS	P	4, NS
365	Jograwas *	P	15, NS	P	31, NS
371	Hemawas *	N	46, NS	N	37, NS
372	Pali	N	12, NS	P	33, NS
374	Desuri	P	35, NS	P	44, NS
375	Kharda *	P	26, NS	P	35, NS
379	Kana *	N	70, NS	N	62, NS
380	Muthana *	N	92, S	N	92, S
382	Sadri *	N	68, S	N	77, NS
388	Sanderao *	N	22, NS	N	28, NS
389	Takhatgarh *	N	15, NS	N	32, NS
391	Ahore	P	9, NS	P	33, NS
409	Danta *	N	5, NS	P	16, NS
410	Ora *	N	30, NS	N	28, NS
411	Sirohi	N	57, NS	N	28, NS
413	Jaswantpura	P	7, NS	P	26, NS
543	Jalore	P	34, NS	P	58, NS
547	Sheoganj *	N	51, NS	N	49, NS
548	Reodhar *	P	56, NS	P	63, NS
561	Bali	P	41, NS	P	64, NS
ACZ IIIa					
58	Galvania Bund *	N	76, NS	N	75, NS
127	Moti Sagar *	N	98, S	N	99, S
128	Nasirda *	N	89, NS	N	92, S
130	Panwar Sagar *	N	96, S	N	96, S
131	Toda Rai Singh	P	68, NS	P	73, NS
132	Tonk	P	92, S	P	86, NS
133	Tonk *	N	70, NS	N	47, NS
135	Kekri	P	59, NS	P	50, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
136	Masuda	P	18, NS	P	13, NS
154	Arain	N	1, NS	P	5, NS
155	Bhinai	P	90, S	P	94, S
156	Gegal	P	1, NS	P	3, NS
157	Goela	N	58, NS	N	32, NS
159	Nasira Bad	P	99, S	P	100, S
160	Sarwar	P	74, NS	P	82, NS
161	Sri Nagar	N	62,NS	N	48, NS
163	Lamba Hari Singh *	N	100, S	N	100, S
164	Tordi Sagar *	N	76, NS	N	63, NS
165	Chhaparwara *	N	95, S	N	97, S
171	Naraina	N	80, NS	N	49, NS
173	Phagi	P	12, NS	P	44, NS
175	Malpura	N	13, NS	P	33, NS
176	Mashi *	N	94, S	N	91, S
177	Pipalu	N	34, NS	P	15, NS
179	Niwai	N	74, NS	N	50, NS
180	Amber	N	38, NS	N	16, NS
181	Bassi	N	9, NS	P	41, NS
182	Chaksu	N	79, NS	N	65, NS
184	Jaipur	N	82, NS	N	73, NS
185	Jaipur (a)	N	33, NS	N	25, NS
186	Kanota *	N	64, NS	N	76, NS
187	Lalsot	N	34, NS	N	12, NS
188	Rahuwas *	P	58, NS	P	44, NS
190	Sanganer	N	75, NS	N	52, NS
220	Baswa	N	96, S	N	87, NS
221	Dausa	N	18, NS	P	35, NS
222	Jamwa Ramgarh	P	95, S	P	90, S
226	Sikrai	N	62, NS	N	35, NS
262	Kotputli	N	46, NS	P	10, NS
263	Paota	P	35, NS	P	70, NS
343	Beawar *	P	10, NS	P	22, NS
344	Mangliawas	P	93, S	P	92, S
345	Pisangan	P	87, NS	P	88, NS
346	Pushkar	P	94, S	P	92, S
423	Ajmer (a)	P	12, NS	N	10, NS
424	Ajmer	P	6,NS	P	25, NS
426	Chomu	N	83,NS	N	87, NS
427	Phulera	P	8,NS	P	56, NS
428	Sambhar	P	10,NS	P	62, NS
577	Galwar *	N	89,NS	N	90, S
ACZ IIIb					
8	Dholpur	N	63, NS	N	44, NS
9	Urmila Sagar *	P	0, NS	N	8, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
158	Kishangarh	N	17, NS	P	19, NS
192	Bamanwas	N	78, NS	N	48, NS
193	Bonli	N	96, S	N	94, S
194	Gangapur City	N	67, NS	N	35, NS
196	Moran Sagar *	N	98, S	N	98, S
197	Kalisil *	N	81, NS	N	84, NS
198	Sapotra	P	32, NS	P	43, NS
199	Angai *	N	93, S	N	96, S
200	Bari	N	72, NS	N	51, NS
202	Sepau	N	92, S	N	77, NS
203	Sirmathura	N	94, S	N	85, NS
204	Talabshahi *	N	69, NS	N	77, NS
206	Ajan *	N	87, NS	N	91, S
208	Bharatpur	N	38, NS	P	23, NS
209	Deeg	N	61, NS	N	28, NS
210	Halena *	N	6, NS	N	15, NS
211	Hingota *	N	20, NS	N	51, NS
212	Kaman	N	71, NS	N	46, NS
213	Kumher	N	68, NS	N	42, NS
214	Nadbai	N	87, NS	N	75, NS
215	Nagar	N	97, S	N	95, S
217	Sewar *	N	86, NS	N	90, S
219	Weir	N	91, S	N	69, NS
228	Mahuwa	N	50, NS	P	16, NS
229	Toda Bhim	N	97, S	N	94, S
230	Baretha *	N	22, NS	N	39, NS
231	Bayana	N	75, NS	N	48, NS
233	Baseri	N	93, S	N	82, NS
234	Roopwas	N	93, S	N	82, NS
235	Hindaun	N	84, NS	N	70, NS
236	Juggar *	N	48, NS	N	19, NS
238	Karauli	N	1, NS	P	22, NS
241	Nadoti	N	78, NS	N	51, NS
243	Alwar	N	85, NS	N	85, NS
244	Govindgarh	P	74, NS	P	79, NS
245	Kathumbar	P	0, NS	P	52, NS
247	Malakhera	N	44, NS	N	8, NS
248	Ramgarh	P	50, NS	P	67, NS
249	Rajgarh	N	73, NS	N	59, NS
250	Siliserh *	P	2, NS	P	38, NS
251	Thanagazi	N	21, NS	P	21, NS
252	Bansur	N	35, NS	N	20, NS
253	Behror	N	68, NS	N	48, NS
254	Kishangarh Bas	P	12, NS	P	34, NS
255	Kotkasim	P	84, NS	P	94 ,S
256	Mandawar	N	14, NS	P	3, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
257	Neemrana	P	6, NS	P	4, NS
258	Sodawas *	N	62, NS	N	66, NS
259	Tapukra	N	83, NS	N	74, NS
260	Tijara	N	90, S	N	85, NS
406	Morel Dam *	P	98, S	P	96, S
541	Pahari	N	55, NS	N	18, NS
673	Dholpur (a)	N	86, NS	N	95, S
ACZ IVa					
4	Bhainsrorgarh	P	90, S	P	89, NS
5	Begun	P	87, NS	P	95, S
6	Gadola *	N	84, NS	N	93, S
53	Bijolia	P	78, NS	P	64, NS
68	Mandalgarh	P	82, NS	P	83, NS
69	Kotri	N	47, NS	N	34, NS
70	Sahada	P	6, NS	P	53, NS
72	Rashmi	N	71, NS	N	59, NS
73	Amet	N	46, NS	P	5, NS
76	Gogunda	P	80, NS	P	87, NS
77	Kherwada	N	3, NS	N	5, NS
78	Nathdwara	P	82, NS	P	87, NS
80	Railmagra	P	9, NS	P	42, NS
81	Rajsamand	P	40, NS	P	69, NS
84	Badgaon *	P	65, NS	P	40, NS
85	Bhadesar	P	60, NS	P	67, NS
86	Badi Sadri	N	86, NS	N	88, NS
87	Bhopalsagar	P	50, NS	P	64, NS
89	Chittaurgarh	P	68, NS	P	83, NS
90	Dungla	N	90, S	N	92, S
92	Gangrar	P	67, NS	P	74, NS
93	Gambhiri *	N	70, NS	N	89, NS
94	Kapasan	P	73, NS	P	82, NS
95	Nimbahera	N	14, NS	N	44, NS
96	Orai *	N	73, NS	N	79, NS
98	Sandesar *	N	25, NS	N	72, NS
99	Bagolia *	P	91 ,S	P	78, NS
102	Maoli	P	96, S	P	92, S
104	Udaipur Dabok (a)	N	35, NS	N	50, NS
108	Vallabhnagar	P	56, NS	P	51, NS
109	Vallabhnagar *	P	21, NS	P	24, NS
111	Bhilwara	N	1, NS	P	24, NS
113	Mandal	P	36, NS	P	55, NS
114	Meja Dam *	N	21, NS	N	19, NS
116	Sawar	P	83, NS	P	84, NS
117	Jahazpur	N	76, NS	N	66, NS
125	Deoli	P	45, NS	P	51, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
134	Jawaja	P	12, NS	P	1, NS
137	Tatgarh	P	53, NS	P	67, NS
138	Vijaynagar	P	98, S	P	98, S
139	Agucha *	P	47, NS	P	37, NS
140	Arwar Dam *	P	97, S	P	96, S
141	Asind	N	88, NS	N	81, NS
142	Badnore	P	58, NS	P	76, NS
143	Banera	P	27, NS	P	48, NS
145	Hurda	N	50, NS	N	24, NS
146	Khari Dam *	P	28, NS	P	26, NS
147	Nahar Sagar *	P	74, NS	P	69, NS
148	Patan *	P	51, NS	P	43, NS
149	Sareri *	N	15, NS	N	21, NS
150	Shahpura	N	21, NS	P	15, NS
151	Ummed Sagar *	N	61, NS	N	90, S
152	Bhim	P	34, NS	P	71, NS
153	Deo Garh	N	49, NS	N	16, NS
280	Chhoti Sadri	N	60, NS	N	85, NS
283	Pratap Garh	P	42, NS	P	35, NS
298	Babalwara *	N	8, NS	N	11, NS
299	Jaisamand *	P	80, NS	P	68, NS
304	Rikhabdeo *	P	53, NS	P	45, NS
306	Sarada	P	79, NS	P	74, NS
307	Som Kagdar *	P	58, NS	P	28, NS
315	Kotra	P	63, NS	P	85, NS
321	Jhadol	P	18, NS	P	15, NS
325	Abu Road	P	69, NS	P	82, NS
328	Kadambari *	N	41, NS	N	34, NS
331	Mount Abu (a)	N	28, NS	N	22, NS
332	Mount Abu	N	56, NS	N	42, NS
333	Pindwara	P	16, NS	P	41, NS
334	Sarupsagar *	N	32, NS	N	32, NS
336	West Banas *	N	40, NS	N	25, NS
384	Kumbhalgarh	P	8, NS	P	30, NS
390	Bhula *	P	91 ,S	P	90, S
651	Bharai *	N	16, NS	P	0, NS
ACZ IVb					
3	Arnod	P	72, NS	P	80, NS
264	Arthuna	P	90, S	P	57, NS
265	Banswara (a)	P	29, NS	P	5, NS
266	Banswara	N	1, NS	N	4, NS
267	Bhungra	N	36, NS	N	56, NS
268	Danpur	P	30, NS	P	17, NS
269	Garhi	P	72, NS	P	79, NS
270	Ghatol	N	33, NS	N	64, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
271	Jagpura	N	42, NS	N	46, NS
273	Loharia	P	85, NS	P	76, NS
274	Mahi Dam *	P	9, NS	P	2, NS
275	Pipalkhunt	N	78, NS	N	77, NS
288	Dhariawad	P	62, NS	P	54, NS
290	Aspur	P	92, S	P	78, NS
292	Dewal	N	85, NS	N	90, S
294	Dungarpur	N	37, NS	N	45, NS
295	Ganeshpur	P	45, NS	P	24, NS
296	Nithawa	P	99, S	P	96, S
297	Sabla	P	94, S	P	87, NS
305	Salumber	P	74, NS	P	69, NS
308	Galiakot	P	60, NS	P	59, NS
309	Sagwara	P	18, NS	P	16, NS
310	Bagidora	N	58, NS	N	55, NS
312	Kushalgarh	P	9, NS	P	10, NS
313	Sallapat	P	4, NS	P	23, NS
314	Shergarh	P	74, NS	P	76, NS
322	Dhambola	P	93, S	P	84, NS
323	Kanba	N	56, NS	N	47, NS
820	Sajjangarh	P	52, NS	P	65, NS
ACZ V					
12	Digod	N	39, NS	N	21, NS
15	Kota A.p. (a)	N	53, NS	N	48, NS
17	Kota Barrage *	N	98, S	N	98, S
19	Ladpura	N	73, NS	N	65, NS
21	Mansarowar *	N	85, NS	N	74, NS
25	Gangdhar	N	44, NS	N	50, NS
26	Aklera	N	84, NS	N	85, NS
31	Asnawar	P	7, NS	P	42, NS
32	Bakani	N	2, NS	P	17, NS
33	Bhimsagar *	P	99, S	P	99, S
34	Dug	N	97, S	N	92, S
36	Jhalawar	N	21, NS	N	7, NS
37	Jhalrapatan	N	87, NS	N	76, NS
38	Khanpur	N	49, NS	N	31, NS
39	Pirawa	N	71, NS	N	59, NS
40	Pachpahar	P	8, NS	P	22, NS
45	Ramganjmandi	N	24, NS	N	5, NS
46	Sangod	N	94 ,S	N	90, S
48	Bundi	N	68, NS	N	51, NS
49	Gudha Dam *	N	68, NS	N	88, NS
50	Hindoli	N	84, NS	N	75, NS
51	Nainwa	N	51, NS	N	55, NS
52	Talera	N	68, NS	N	58, NS

WRIS Code	Station Name	Monsoon Months (JJAS) Positive (P) /Negative (N) Trend	Monsoon Months Rainfall (JJAS) Confidence level % , Significance #	Annual Rainfall Positive(P)/	Annual Rainfall Confidence level % , Significance#
59	Atru	N	97, S	N	91, S
60	Baran	N	99, S	N	93, S
61	Chhabra	N	40, NS	N	35, NS
62	Chhipabarod	N	54, NS	P	1, NS
63	Kishanganj	N	81, NS	N	42, NS
64	Mangrol	N	60, NS	N	43, NS
65	Pipalda	N	98, S	N	96, S
66	Ummed Sagar *	N	79, NS	N	79, NS
120	Khandar	N	89, NS	N	56, NS
122	Sawai Madhopur	P	26, NS	P	76, NS
162	Chandsen *	N	5, NS	N	28, NS
178	Dheel *	N	26, NS	N	16, NS

(a) - IMD stations, * - Water Resources Dept. Stations, No suffix - Revenue Dept. stations
# - Significance: S - significant trend; NS - insignificant trend.

Source: WRD Daily Rainfall Data (1957-2010)

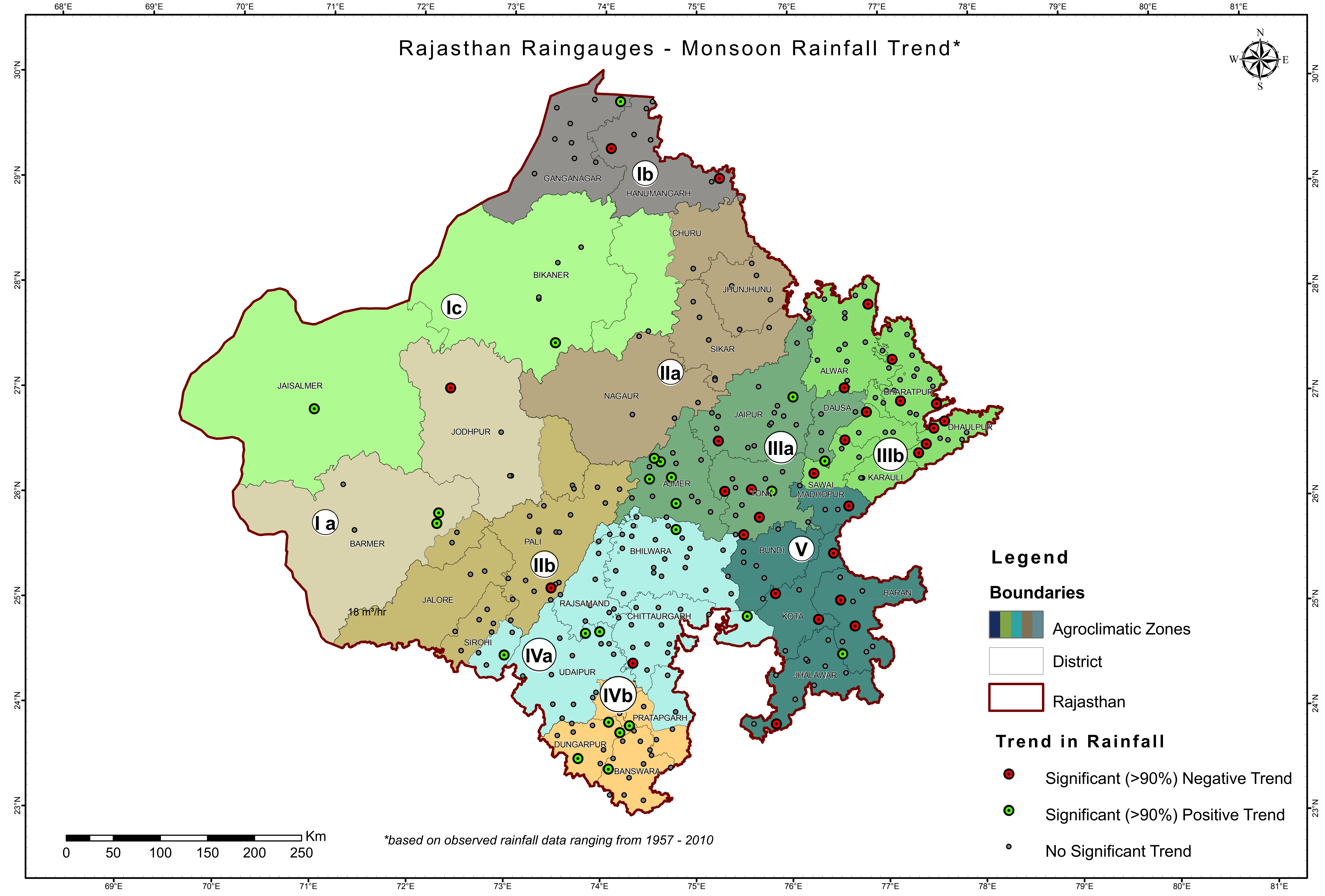
7.12.2 Conclusions

Rainfall in Rajasthan can be termed erratic on the basis of the analysis done on the raingauge stations maintained by different departments, with high temporal as well as spatial variability, as can be seen from Figure 7.55 below. Green dots in this figure signify stations with positive or increasing trends, while red dots signify decreasing trend at a confidence level greater than 90%. The rest of the stations show statistically insignificant or no trend. Among the significant stations, 24 are showing an increasing trend while 28 show a decreasing trend. The stations lying in the eastern region of Rajasthan have strong statistically significant negative trends while statistically significant positive trends are observed in the south of Rajasthan.

There are many factors that can affect the rainfall over an area. Some of the major factors are atmospheric pressure variation, orography, temperature variation, relative humidity, vegetative cover, and there may be some instrument-related and human errors in the rainfall observations. Some of the instrument-related and human errors include a faulty instrument, instrument type, instrument height, type of observation (manual or automatic) and method of measurement.

Figure 7.55 presents a summary of the observed trends in monsoon rainfall over the State and the statistical significance of these trends.

Figure 7.55

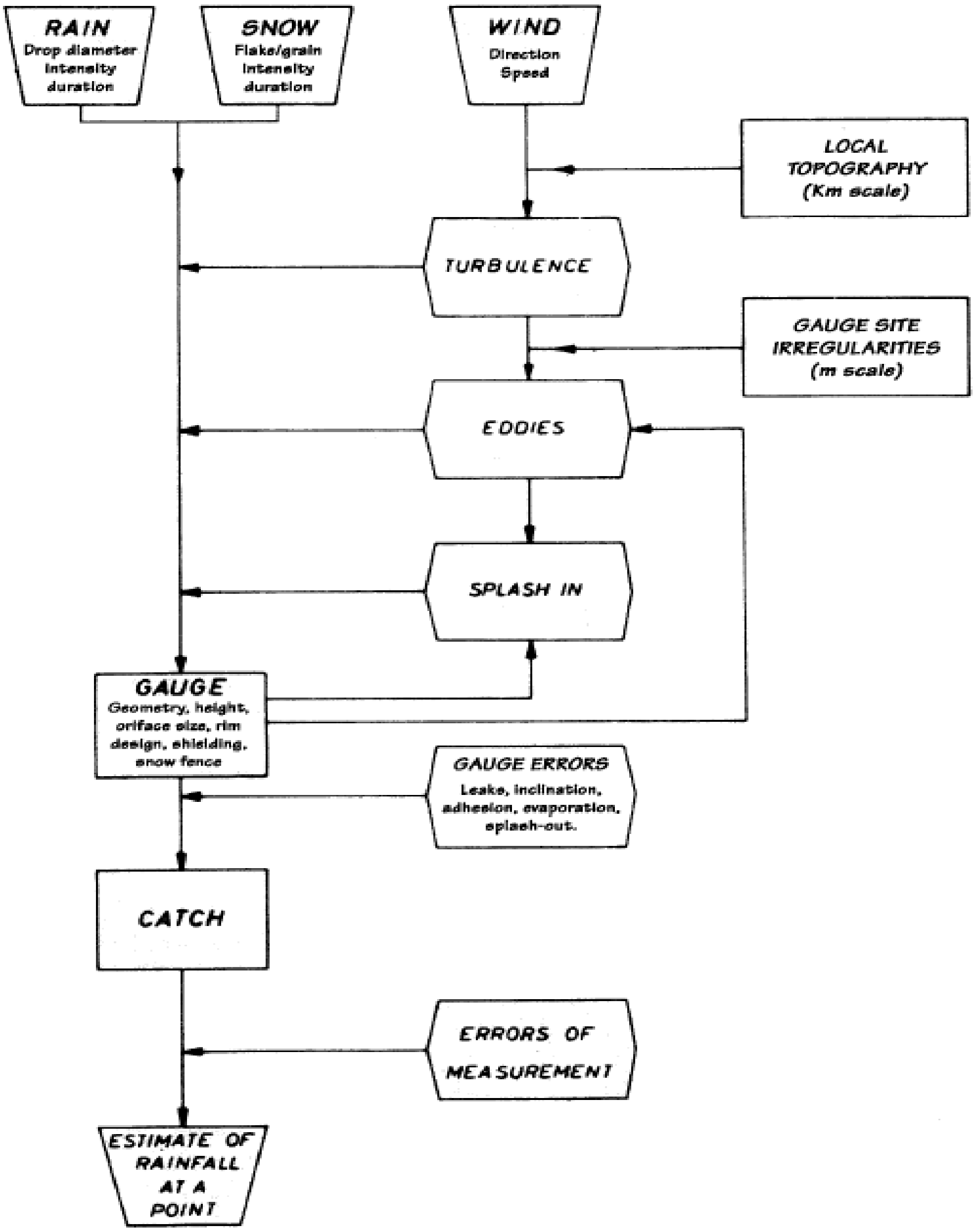

Rajasthan Raingauges - Monsoon Rainfall Trend*
N
S
E
W
GANGANAGAR
HANUMANGARH
Ib
CHURU
BIKANER
Ic
JHUNJHUNU
SIKAR
IIa
JAISALMER
NAGAUR
ALWAR
BHARATPUR
DAUSA
JAIPUR
IIIa
IIIb
DHAULPUR
JODHPUR
KARAULI
SAWAI MADHOPUR
AJMER
TONK
I a
BARMER
PALI
BHILWARA
BUNDI
V
IIb
JALORE
18 m³/hr
RAJSAMAND
CHITTAURGARH
KOTA
BARAN
SIROHI
IVa
UDAIPUR
JHALAWAR
IVb
PRATAPGARH
DUNGARPUR
BANSWARA
Km
0
50
100
150
200
250
*based on observed rainfall data ranging from 1957 - 2010
Legend
Boundaries
Agroclimatic Zones
District
Rajasthan
Trend in Rainfall
Significant (>90%) Negative Trend
Significant (>90%) Positive Trend
No Significant Trend
68°E
69°E
70°E
71°E
72°E
73°E
74°E
75°E
76°E
77°E
78°E
79°E
80°E
81°E
23°N
24°N
25°N
26°N
27°N
28°N
29°N
30°N

7.12.3 Factors Affecting the Observed Rainfall Trends

There are many factors which can affect the rainfall over an area. Some of the major factors are atmospheric pressure variation, orography, temperature variation, relative humidity, vegetative cover, etc., and there may be some instrument-related and human errors in the rainfall observations. Some of the instrument-related and human errors include a faulty instrument, instrument type, instrument height, type of observation (manual or automatic) and method of measurement.

Figure 7.56 illustrates the factors affecting the catch of a rainfall gauge, which can have a significant impact on rainfall observations and thereby on the trends in that gauging station records.

Figure 7.56 Factors Affecting Rainfall Gauge Catch



Source: National Snow and Ice Data Centre, National Oceanic and Atmospheric Administration (NOAA).

7.13 District-wise statistics of Monthly Rainfall and Number of Rainy Days

Tables 7.37 and 7.38 present district-wise data on normal monthly rainfall and number of rainy days. These long term District normal values (IMD District Normal, 1950-1980) are used for evaluating Agro Climatic Zone wise Normal Rainfall and Normal number of rainy days. Sample calculation is presented in Table 7.40.

Table 7.37 District-Wise IMD Monthly Normal Rainfall (1950 to 1980), mm

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ajmer	8.9	5.0	7.7	1.8	9.8	58.5	210.6	187.7	94.5	7.5	5.6	4.2	601.8
Alwar	12.7	11.8	9.0	4.7	15.3	58.1	180.4	199.4	137.1	19.3	2.7	6.8	657.3
Banswara	3.5	2.6	2.2	0.6	5.8	95.5	33.4	301.7	173.0	24.1	5.4	2.5	950.3
Baran	8.2	3.6	3.3	2.7	7.5	81.3	316.1	298.0	126.7	15.0	6.4	5.0	873.8
Barmer	2.1	3.1	3.7	1.2	7.4	19.7	85.8	103.3	34.8	2.6	0.9	1.4	266.0
Bharatpur	10.7	11.9	8.9	4.7	9.2	45.3	200.0	225.1	122.1	17.5	2.7	5.8	663.9
Bhilwara	5.6	2.4	4.9	1.0	2.4	52.0	228.2	248.5	113.4	19.3	1.6	3.9	683.2
Bikaner	3.4	9.6	8.0	1.2	10.5	17.4	63.9	58.8	60.3	2.6	2.6	4.7	243.0
Bundi	7.0	3.9	4.1	2.1	8.3	65.4	286.7	260.9	113.0	15.5	3.0	3.5	773.4
Chittorgarh	6.8	1.6	5.9	1.3	8.7	61.3	280.1	300.0	151.3	17.7	3.5	3.3	841.5
Churu	9.8	6.6	5.6	4.3	10.6	35.4	108.1	109.1	50.5	8.4	1.6	4.7	354.7
Dausa	9.1	7.6	5.7	2.2	9.9	42.1	189.3	180.9	89.9	14.3	3.4	6.6	561.0
Dholpur	14.6	8.2	7.3	3.9	8.0	55.0	221.1	264.5	131.0	22.2	3.5	5.2	744.5
Dungarpur	3.0	1.7	2.3	1.5	8.5	88.7	271.3	197.3	130.1	18.1	5.2	1.2	728.9
Ganganagar	7.5	6.9	10.6	3.4	8.1	25.0	61.9	67.5	28.7	1.3	0.6	4.9	226.4
Hanumangarh	8.7	9.9	6.7	4.4	6.5	27.3	83.6	77.3	40.0	4.3	0.5	4.3	273.5
Jaipur	3.5	12.0	2.3	2.1	13.6	28.8	160.9	252.5	72.6	7.5	3.8	4.2	563.8
Jaisalmer	2.6	5.1	3.6	2.3	7.1	14.0	57.7	66.9	21.9	1.2	1.4	1.7	185.5
Jalore	2.5	3.9	3.7	1.2	7.3	30.1	115.9	135.3	58.5	9.5	1.1	1.0	370.0
Jhalawar	12.2	0.2	7.1	1.3	1.0	49.4	260.2	319.3	172.3	10.5	7.2	3.6	844.3
Jhunjhunu (P)	8.4	9.1	6.8	5.4	13.4	40.6	127.5	114.5	61.5	10.4	2.0	5.4	405.0
Jodhpur	4.6	2.8	3.6	1.0	5.2	24.5	101.7	128.9	36.2	3.0	1.5	0.7	313.7
Karauli	10.6	6.9	6.0	3.0	9.7	49.0	232.3	260.5	105.2	18.5	3.6	4.1	709.4
Kota	5.5	0.1	5.2	1.0	9.2	53.0	257.7	237.7	150.5	6.5	4.4	1.6	732.4
Nagaur	5.1	7.4	5.4	2.8	12.0	29.4	92.8	107.7	39.4	4.9	1.0	3.9	311.8
Pali	3.2	3.6	2.8	1.4	5.6	40.7	128.3	167.6	62.4	5.9	1.4	1.5	424.4
Pratapgarh	3.7	2.8	4.1	5.3	8.6	100.9	272.9	261.4	152.8	23.7	6.8	1.9	844.9
Rajsamand	5.6	1.3	6.8	0.6	6.1	55.5	178.3	178.4	116.6	15.8	1.6	1.2	567.8

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Sawai Madhopur	8.2	5.1	6.1	1.4	6.2	68.8	316.9	318.4	124.7	10.8	2.1	4.7	873.4
Sikar	8.6	7.6	7.3	3.2	14.7	38.9	142.9	144.1	54.8	8.3	3.9	6.0	440.3
Sirohi	3.1	4.4	4.2	2.2	12.6	46.4	202.6	212.0	90.1	10.1	2.2	1.2	591.1
Tonk	7.7	5.2	4.6	2.0	9.8	59.4	237.9	225.6	94.4	13.6	4.2	3.9	668.3
Udaipur	3.1	1.3	17.3	3.6	6.2	78.1	190.1	203.9	124.2	12.7	3.7	0.8	645.0
State Mean	5.9	4.3	5.6	2.0	7.7	47.6	190.2	193.4	100.7	11.0	3.1	3.6	575.1

Table 7.38 District-Wise Normal Number of Rainy Days, Days

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ajmer	1	1	0	0	1	3	8	8	4	1	0	0	26
Alwar	1	1	1	1	1	3	9	9	5	1	0	1	32
Banswara	0	0	0	0	0	4	14	12	6	1	0	0	39
Baran	1	1	0	0	1	5	14	12	6	1	1	1	42
Barmer	0	0	0	0	1	1	4	4	2	0	0	0	13
Bharatpur	1	1	1	1	1	3	10	11	6	1	0	1	35
Bhilwara	1	0	0	0	1	3	11	10	4	0	0	0	32
Bikaner	0	1	1	0	1	2	5	5	2	0	0	0	17
Bundi	1	1	0	0	1	4	12	11	5	1	0	0	35
Chittorgarh	1	0	0	0	1	4	11	11	5	1	0	0	34
Churu	1	1	1	0	1	2	5	5	3	0	0	0	19
Dausa	1	1	1	0	1	3	10	10	5	1	0	1	33
Dholpur	1	1	1	1	1	3	12	12	6	1	0	1	39
Dungarpur	0	0	0	0	1	4	12	11	5	1	0	0	35
Ganganagar	1	1	1	1	1	2	4	4	2	0	0	0	16
Jaipur	1	1	1	0	1	3	10	9	4	1	0	0	32
Jaisalmer	0	0	0	0	0	1	3	3	1	0	0	0	8
Jalore	0	0	0	0	0	2	6	6	3	0	0	0	19

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Jhalawar	1	1	1	0	1	6	14	12	7	1	1	1	44
Jhunjhunu	1	1	1	1	2	3	7	7	3	1	0	1	27
Jodhpur	0	1	0	0	1	2	5	6	2	0	0	0	18
Kota	1	1	0	0	1	5	13	12	6	1	1	1	41
Nagaur	1	1	1	0	1	3	6	6	3	0	0	0	22
Pali	0	1	0	0	1	3	7	7	3	1	0	0	23
Rajsamand	0	0	0	0	0	2	8	6	4	0	0	0	21
Sawai Madhopur	1	1	1	0	1	4	11	11	5	1	0	1	36
Sikar	1	1	1	1	1	3	9	9	4	0	0	1	30
Sirohi	1	1	0	0	1	3	10	9	4	1	0	0	29
Tonk	1	1	1	0	1	3	10	10	5	1	0	0	33
Udaipur	0	0	0	0	1	3	10	8	5	1	0	0	28
Karauli	1	1	1	0	1	4	11	11	5	1	0	1	35
Pratapgarh	0	0	0	0	1	4	12	10	5	1	0	0	34
Hanumangarh	1	1	1	1	1	2	4	4	2	0	0	0	17
Rajasthan East	1	1	1	0	1	4	11	10	5	1	0	0	34
Rajasthan West	1	1	0	0	1	2	5	5	2	0	0	0	17
Rajasthan State	1	1	1	0	1	3	9	9	4	1	0	0	29

Note: A rainy day is a day on which 2.5 millimetres or more of rain are recorded.

7.14 Trend Analysis of Number of Rainy Days per Agroclimatic Zone

Table 7.39 shows the number of rainy days in the various agroclimatic zones and their positive or negative trend values over the study period of 54 years, 1957 - 2010.

A day is considered a rainy day when it receives rainfall greater than 2.5 mm.

The analysis shows that ACZ V has the highest number of mean annual rainy days, 56, while zone Ia has the lowest number of rainy days, 24.

None of the ACZs shows a significant trend, as their Tau values as well as their confidence levels are very low (< 90 %).

Table 7.39 Number of Rainy Days in Various Agroclimatic Zones

ACZ → Year↓	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
1957	24	23	31	47	31	46	53	43	45	53
1958	21	26	24	44	29	58	65	64	60	71
1959	24	28	20	35	35	47	50	4	49	52
1960	24	28	20	35	35	47	50	43	49	52
1961	35	30	41	48	46	63	76	71	70	80
1962	28	22	25	39	26	43	48	51	53	58
1963	18	27	12	36	31	42	52	52	52	61
1964	24	31	31	38	32	46	53	52	53	57
1965	19	16	20	26	21	26	30	34	37	35
1966	19	35	30	39	27	43	51	45	29	48
1967	32	38	37	55	46	60	65	61	59	74
1968	8	15	13	25	14	31	37	31	29	38
1969	12	19	15	27	12	36	43	40	51	50
1970	26	31	38	54	49	58	60	67	60	62
1971	22	16	27	56	26	62	73	53	53	68
1972	20	19	20	26	19	37	37	37	36	41
1973	33	26	34	39	56	62	52	70	72	69
1974	15	16	20	38	24	37	42	43	31	54
1975	48	37	46	59	58	72	74	81	68	84
1976	33	36	32	45	43	54	52	56	61	63
1977	25	40	39	65	43	68	74	64	62	59
1978	36	34	30	50	43	59	59	54	59	59
1979	23	21	24	29	37	38	35	58	45	51
1980	22	25	21	44	40	47	58	47	52	51
1981	25	30	22	30	27	41	43	53	55	45
1982	27	35	35	51	36	49	64	52	50	56
1983	41	45	46	57	49	59	77	72	63	77
1984	14	32	21	28	34	42	48	43	47	45
1985	12	27	23	34	20	38	55	41	32	50

ACZ → Year↓	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
1986	13	27	23	33	13	34	46	35	29	49
1987	14	25	24	24	10	34	32	34	31	39
1988	25	35	28	47	29	42	63	47	53	66
1989	24	15	21	29	31	40	33	55	49	48
1990	26	23	26	40	33	53	58	59	61	62
1991	17	10	19	33	28	37	38	39	33	45
1992	32	30	39	46	39	45	63	51	51	50
1993	19	24	27	40	24	41	48	40	46	59
1994	38	15	26	35	45	56	53	68	73	71
1995	20	18	37	48	25	52	57	44	46	51
1996	25	13	35	59	35	59	65	55	54	61
1997	36	20	48	59	31	59	66	54	58	76
1998	26	26	24	44	26	50	57	53	57	57
1999	14	13	19	28	21	35	49	40	45	51
2000	16	11	17	31	27	38	45	39	27	43
2001	23	31	26	51	33	46	58	46	40	49
2002	13	9	12	23	21	25	37	32	31	34
2003	32	32	32	53	41	61	69	65	55	60
2004	17	23	18	39	34	43	45	45	48	47
2005	21	28	30	43	31	38	40	46	35	45
2006	27	33	23	29	42	38	40	57	65	53
2007	25	35	33	46	31	43	52	47	49	57
2008	29	40	32	53	32	56	78	55	47	60
2009	16	24	22	29	24	36	44	34	45	44
2010	36	46	42	64	51	62	68	70	56	64
Mean	24	26	27	41	32	47	53	51	49	56
Positive (P) or Negative (N) trend	P	P	P	P	P	N	P	P	N	N
Confidence Level, %	17.0#	18.0#	39.0#	41.0#	24.0#	57.0#	2.0#	24.0#	62.0#	78.0#

# indicates insignificant trend as the confidence level is less than 90%.

Source: WRD Daily Rainfall Data (1957-2010)

7.15 Agroclimatic Zone-wise Normal Rainfall and Normal Number of Rainy Days

ACZ-wise normal rainfall has been evaluated with a GIS overlay and interpolation techniques, using the districts normal rainfall. Weighted sum method was used for evaluating rainfall and rainy days per agroclimatic zone. Here, using the GIS-overlay method agroclimatic zones and district boundaries intersected and the area for each individual polygon was calculated. Weighing of each individual intersected polygon with respect to agroclimatic zone area was calculated by following formula.

Weight of the district (W) = Area of individual polygon / Area of Agroclimatic Zone

Weighted rainfall and rainy days were calculated as

monthly rain for an ACZ = $\sum DR_i \times W_i$

Where:

DR = district normal rainfall, mm

W = weight of the district

A sample computation for January monthly rainfall in agroclimatic zone Ia is presented in Table 7.40.

Table 7.40 Sample Computation for January Monthly Rainfall in Agroclimatic Zone Ia

ACZ	ACZ Area, km^2	Polygon area, km^2	District	Weight	Normal Rainfall, mm	Weighted Rainfall, mm
1	2	3	4	5=3/2	6	7=5×6
Ia	45,719.1	19,238.5	Jodhpur	0.4	4.6	1.84
	45,719.1	26,480.6	Barmer	0.6	2.1	1.26
Total						3.10

Source: IMD District Normals (30 years duration, 1950-1980)

Similarly, monthly rainfalls for various agroclimatic zones were calculated.

District weights for various agroclimatic zones are presented in the Table 7.41.

Table 7.41 District Weights of Various Agroclimatic Zones

Agroclimatic Zones									
Ia		Ib		Ic		IIa		IIb	
District	Weight	District	Weight	District	Weight	District	Weight	District	Weight
Barmer	0.58	Ganganagar	0.52	Bikaner	0.39	Churu	0.15	Barmer	0.07
Jodhpur	0.42	Hanumangarh	0.48	Churu	0.11	Jhunjhunu	0.16	Jalore	0.34
				Jaisalmer	0.50	Nagaur	0.48	Jodhpur	0.11
						Sikar	0.21	Pali	0.39
								Sirohi	0.10
Total	1.00	Total	1.00	Total	1.00	Total	1.00	Total	1.00

Agroclimatic Zones									
IIIa		IIIb		IVa		IVb		V	
District	Weight	District	Weight	District	Weight	District	Weight	District	Weight
Ajmer	0.28	Alwar	0.34	Ajmer	0.01	Banswara	0.37	Baran	0.26
Dausa	0.10	Bharatpur	0.21	Bhilwara	0.28	Dungarpur	0.32	Bundi	0.22
Jaipur	0.38	Dausa	0.02	Chittorgarh	0.21	Pratapgarh	0.18	Jhalawar	0.24

Agroclimatic Zones									
IIIa		IIIb		IVa		IVb		V	
District	Weight	District	Weight	District	Weight	District	Weight	District	Weight
Tonk	0.24	Dholpur	0.12	Pratapgarh	0.06	Udaipur	0.13	Kota	0.19
		Karauli	0.20	Rajsamand	0.12			Sawai Madhopur	0.10
		Sawai Madhopur	0.10	Sirohi	0.05				
				Udaipur	0.27				
Total	1.00	Total	1.00	Total	1.00	Total	1.00	Total	1.00

Source: Administrative boundaries of Rajasthan

It is evident from Table 7.42 below that highest and lowest annual normal rainfall values occur in the Humid South-Eastern plain, Zone V (818.2 mm) and the Hyper Arid Irrigated Western Plain, Partially, Zone Ic (226 mm), respectively, while the annual normal number of rainy days is highest in Zone V, Humid South-Eastern Plain, with 41 days, and the lowest in Zone Ic, Hyper-Arid Irrigated Western Plain, Partially, with 13 days, as seen in Table 7.43.

From Table 7.39 and 7.43 it can be observed that mean annual number of rainy days (as evaluated from WRD Rainfall data source, 1957-2010) is higher than Normal number of rainy days (IMD Climatic Normals, 1950-1980) for all the agro climatic zones.

Table 7.42 Agroclimatic Zone-Wise Monthly and Annual Normal Rainfall, mm

Agroclimatic Zone (ACZ)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Ia	Arid Western	3.2	3.0	3.7	1.1	6.5	21.7	92.5	114.1	35.4	2.8	1.2	1.1	286.1
Ib	Irrigated North Western Plain	8.1	8.3	8.7	3.9	7.3	26.1	72.3	72.2	34.1	2.7	0.6	4.6	249.0
Ic	Hyper-Arid Irrigated Western Plain, Partially	3.7	7.0	5.5	2.1	8.8	17.6	65.5	68.2	40.0	2.5	1.9	3.2	226.2
IIa	Transitional Plain of inland drainage	7.1	7.6	6.0	3.5	12.6	34.1	111.1	116.6	47.8	7.0	1.9	4.7	360.0
IIb	Transitional Plain of Luni Basin	3.0	3.7	3.4	1.4	6.9	34.6	125.8	152.7	59.2	7.0	1.4	1.2	400.2
IIIa	Semi-Arid Eastern Plain	6.6	7.9	4.7	2.0	11.2	45.9	196.4	220.7	85.8	9.7	4.4	4.4	599.6
IIIb	Flood Prone Eastern Plain	11.6	9.6	7.8	3.9	11.0	53.9	213.9	236.8	124.5	18.2	2.9	5.6	699.7
IVa	Sub humid Southern Plain	4.9	1.9	8.6	2.0	6.2	64.1	223.8	237.0	125.6	16.4	2.9	2.3	695.9
IVb	Humid southern Plain	3.3	2.2	4.5	2.1	7.2	92.1	172.7	248.8	149.5	20.7	5.4	1.8	710.3
V	Humid South-Eastern Plain	8.4	2.3	5.0	1.8	6.3	63.8	285.6	285.5	138.8	12.0	5.1	3.7	818.2

Source: IMD district normals (30 years duration, 1950-1980)

Table 7.43 Agroclimatic Zone-Wise Normal Number of Rainy Days, Days

Agroclimatic Zone (ACZ)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Ia	Arid Western	0	0	0	0	1	1	4	5	2	0	0	0	14
Ib	Irrigated North Western Plain	1	1	1	1	1	2	4	4	2	0	0	0	17
Ic	Hyper Arid Irrigated Western Plain Partially	0	0	0	0	0	1	4	4	2	0	0	0	13
IIa	Transitional Plain of inland drainage	1	1	1	0	1	3	7	7	3	0	0	0	24
IIb	Transitional Plain of Luni Basin	0	1	0	0	1	2	7	7	3	0	0	0	20
IIIa	Semi-Arid Eastern Plain	1	1	1	0	1	3	9	9	4	1	0	0	31
IIIb	Flood Prone Eastern Plain	1	1	1	1	1	3	10	10	5	1	0	1	36
IVa	Sub humid Southern Plain	1	0	0	0	1	3	10	9	5	1	0	0	29
IVb	Humid southern Plain	0	0	0	0	1	4	12	11	5	1	0	0	34
V	Humid South-Eastern Plain	1	1	0	0	1	5	13	12	6	1	1	1	41

Source: IMD district normals (30 years duration, 1950-1980)

7.16 Agroclimatic Zone-wise Rainfall Intensity Analysis

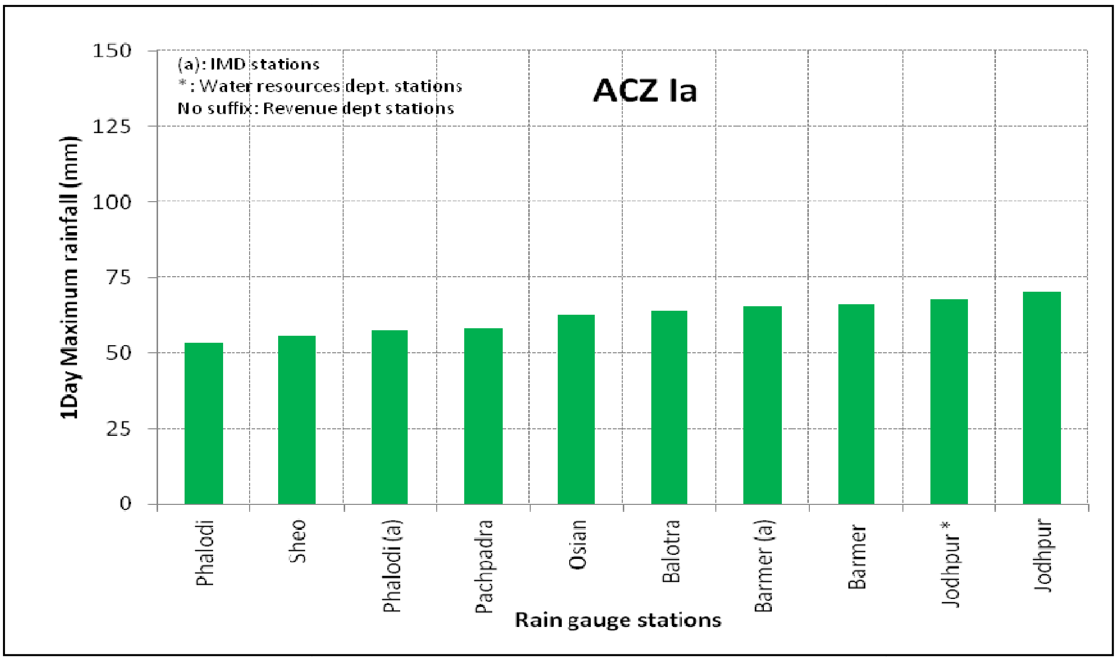
To explore if there are trends in the rainfall intensity in various ACZs, sub-daily (hourly) rainfall data are required for longer and continuous periods, to derive rainfall intensities at various raingauge stations. In the absence of such sub-daily rainfall data, an analysis of change in the pattern of longer-duration rainfall of 1 to 5 days has been performed.

Annual 1-day, 2-day, 3-day, 4-day and 5-day maximum rainfall values are used by design engineers and hydrologists for economic planning, design of hydrologic structures and determination of drainage parameters.

The daily rainfall data for the period of 54 years (1957 - 2010) were used for this analysis. 1-day, 2-day, 3-day, 4-day and 5-day consecutive rainfall figures were computed, by summing up the rainfall of corresponding days. 1-day maximum rainfall events are considered as highest intensity rainfall that has occurred over a day, which creates high runoffs and soil erosion, and can generate flash floods that create huge losses of life and property.

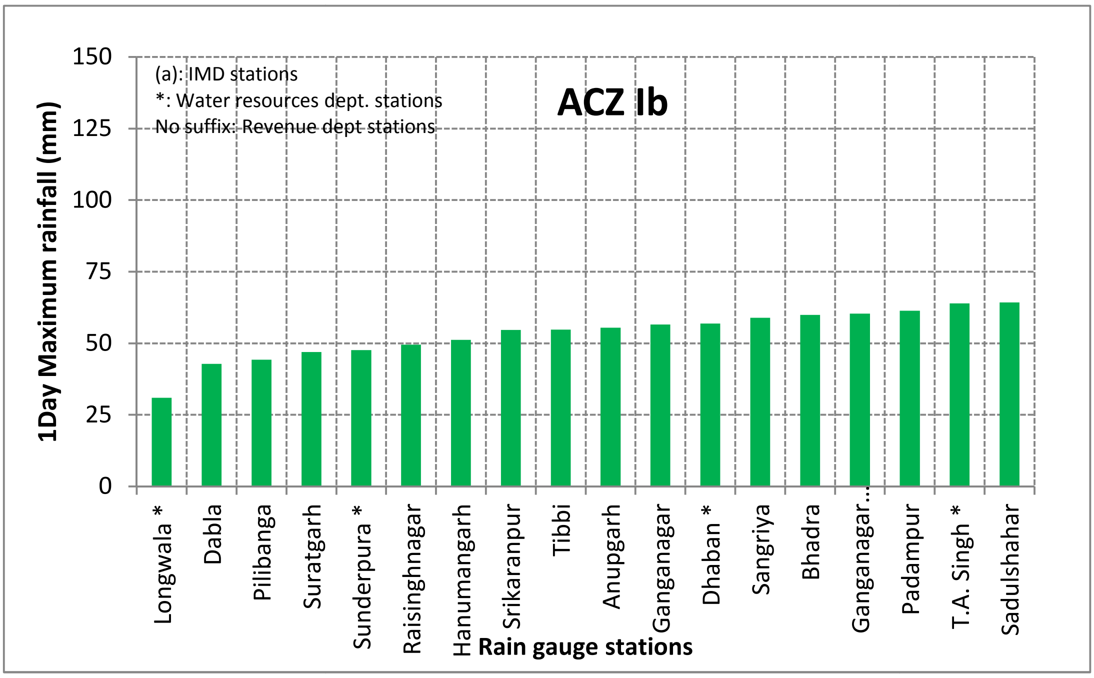
Figures 7.57 to 7.67 show mean 1-day maximum rainfall at various raingauge stations within each of the agroclimatic zones. Mean values of two to five consecutive days maximum rainfall are presented in Appendix 10 (Volume 2 of this report) along with other statistical parameters.

Figure 7.57 Mean 1 Day Maximum Rainfall at Various Raingauge Stations in ACZ Ia



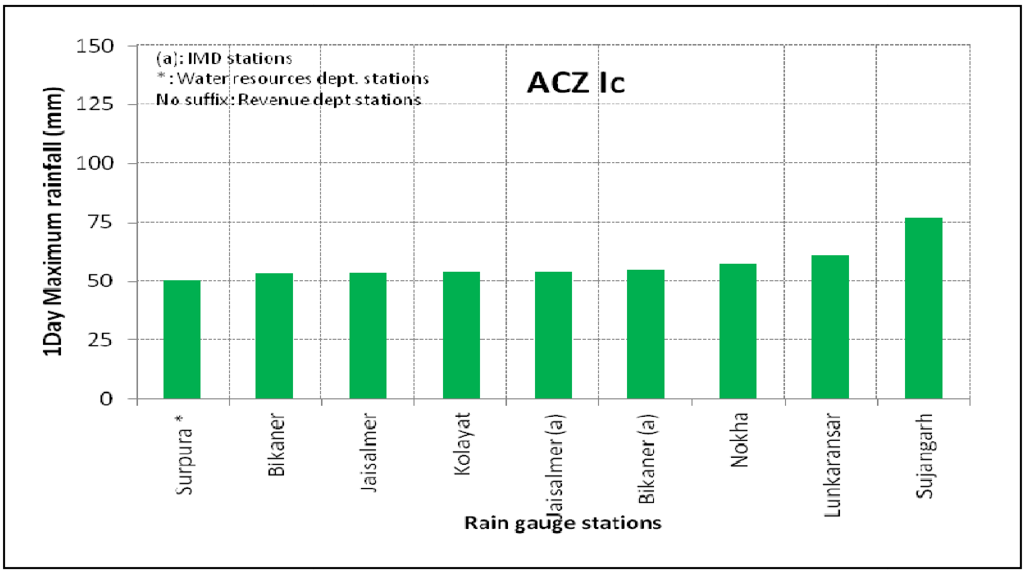
In ACZ Ia the highest mean 1-day maximum rainfall is observed at Jodhpur raingauge station, having a value of 70.4 mm.

Figure 7.58 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ Ib



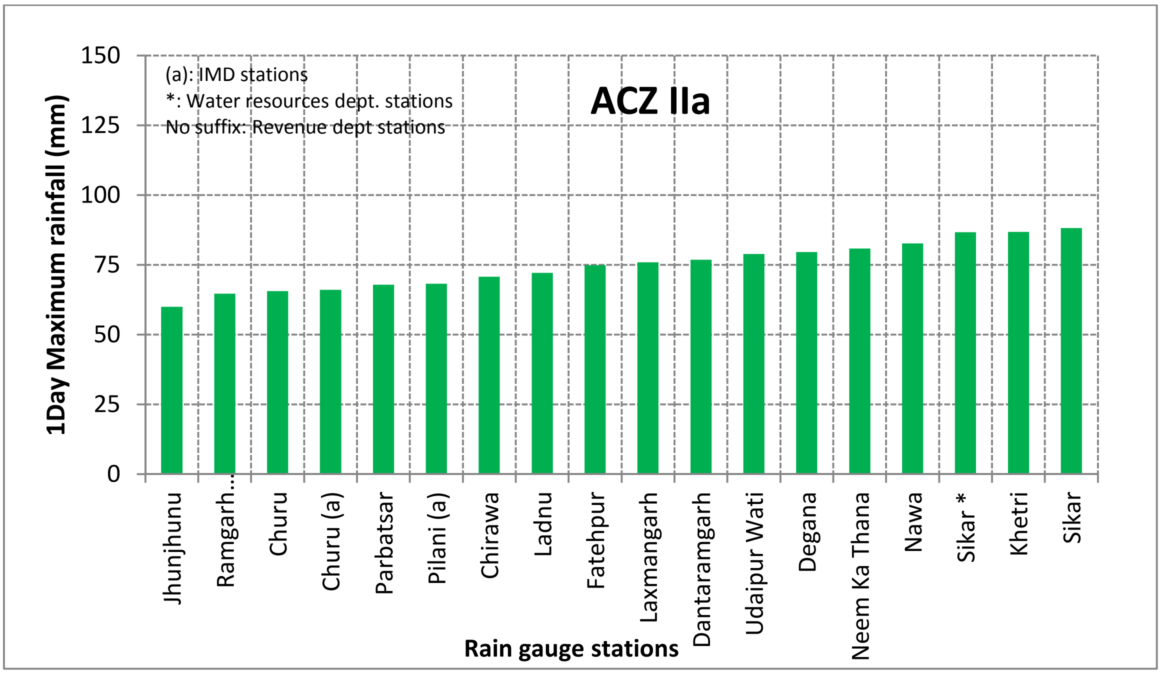
In ACZ Ib Sadulshahar raingauge station shows the highest mean 1-day maximum rainfall, 64.3 mm, while station Longwala shows the lowest mean value of 31 mm.

Figure 7.59 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ Ic



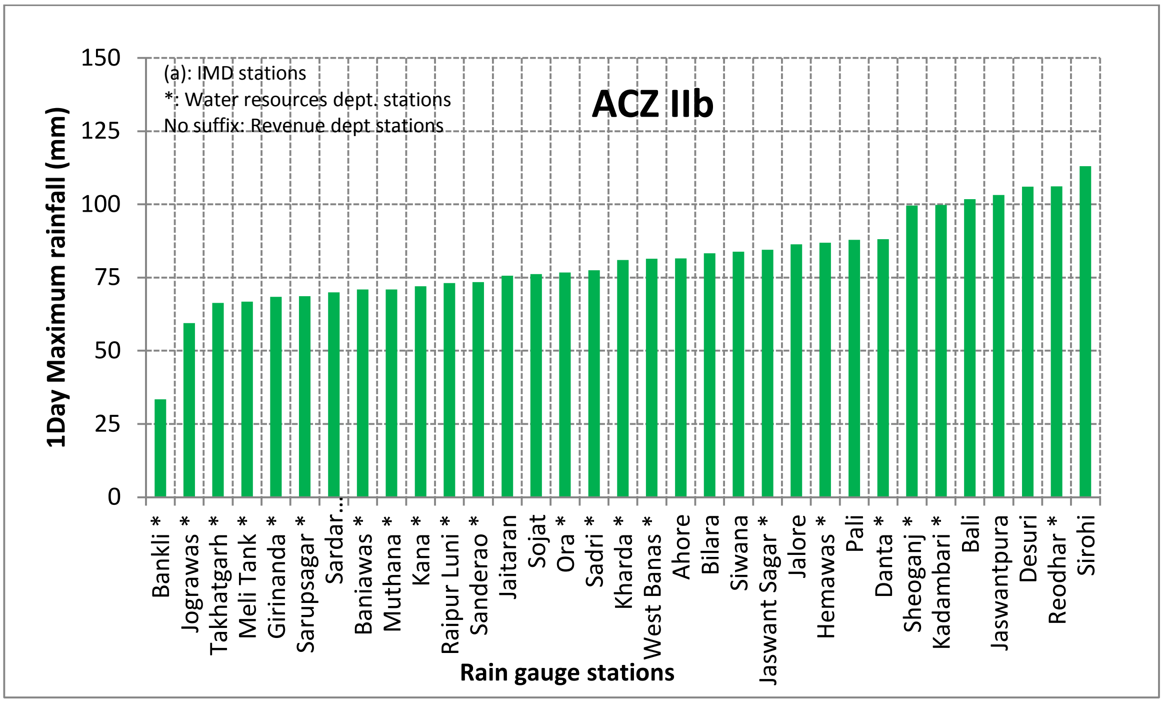
In ACZ Ic, the highest mean 1-day maximum rainfall was recorded in Sujangarh station, with a value of 76.6 mm, while Surpura station shows the lowest mean value of 50.6 mm.

Figure 7.60 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IIa



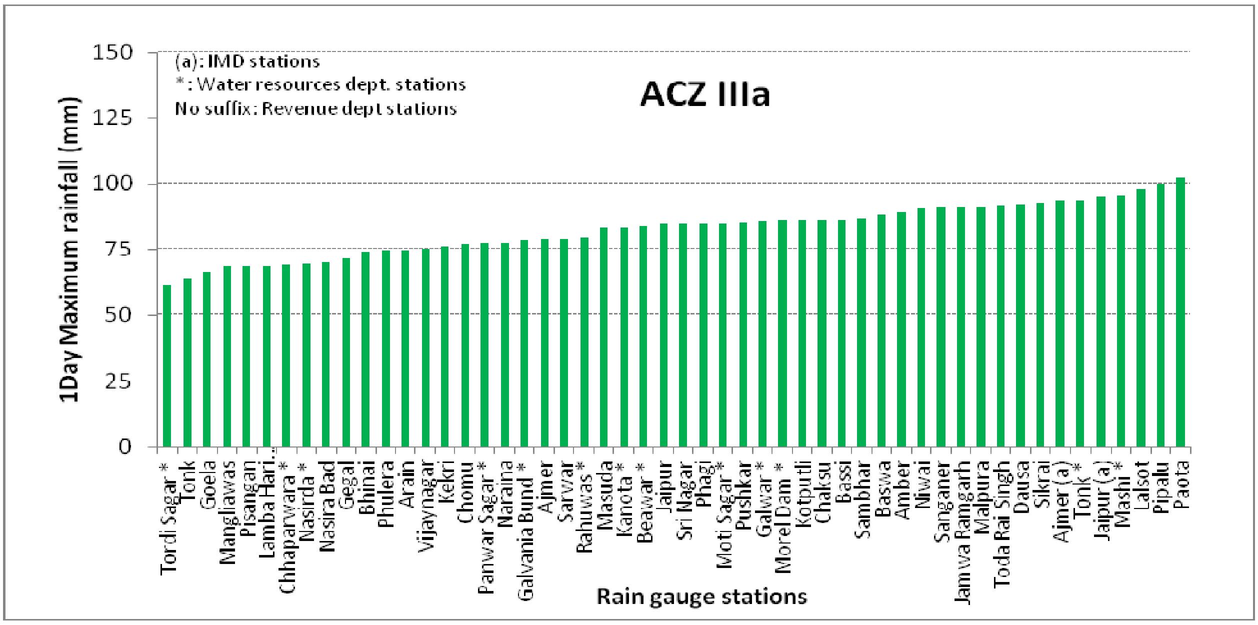
Highest mean 1-day maximum rainfall in ACZ IIa was observed in Sikar station, with a value of 88.2 mm.

Figure 7.61 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IIb



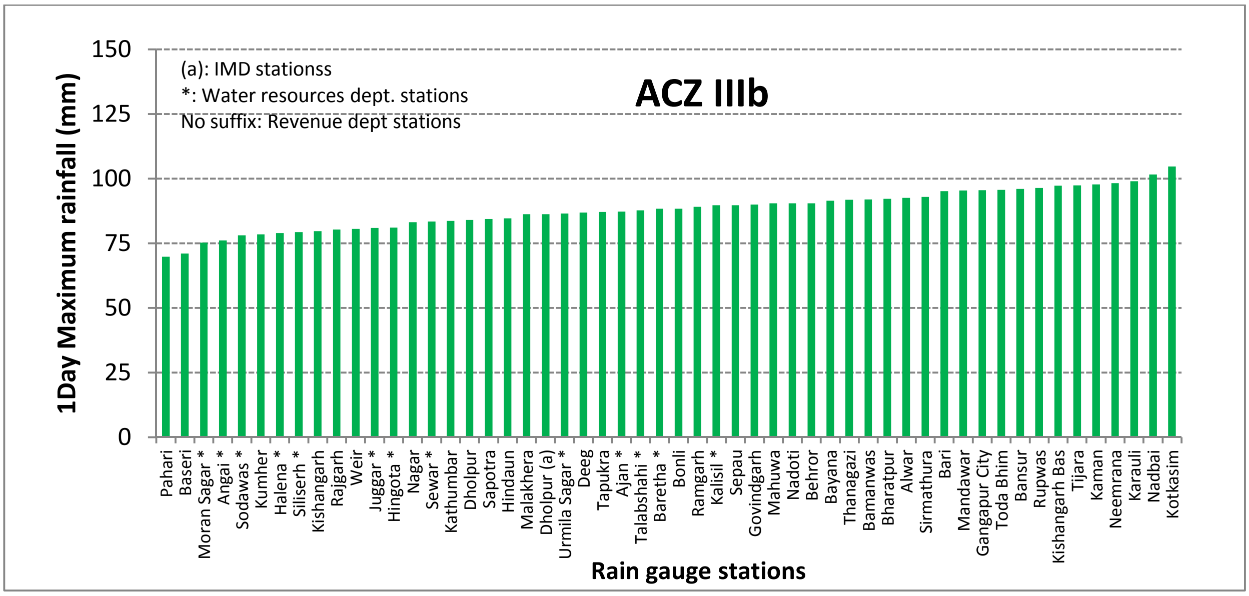
In ACZ IIb, the highest mean 1-day maximum rainfall was recorded in Sirohi station, attaining a value of 113 mm.

Figure 7.62 Mean 1 day Maximum Rainfall at Various Raingauge Stations in ACZ IIIa



Raingauge station Paota shows the highest mean 1-day maximum rainfall in ACZ IIIa, with a value of 102.4 mm.

Figure 7.63 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IIIb



The highest mean 1-day maximum rainfall in ACZ IIIb was observed in station Kotkasim, with a value of 104.7 mm.

Figure 7.64 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IVa

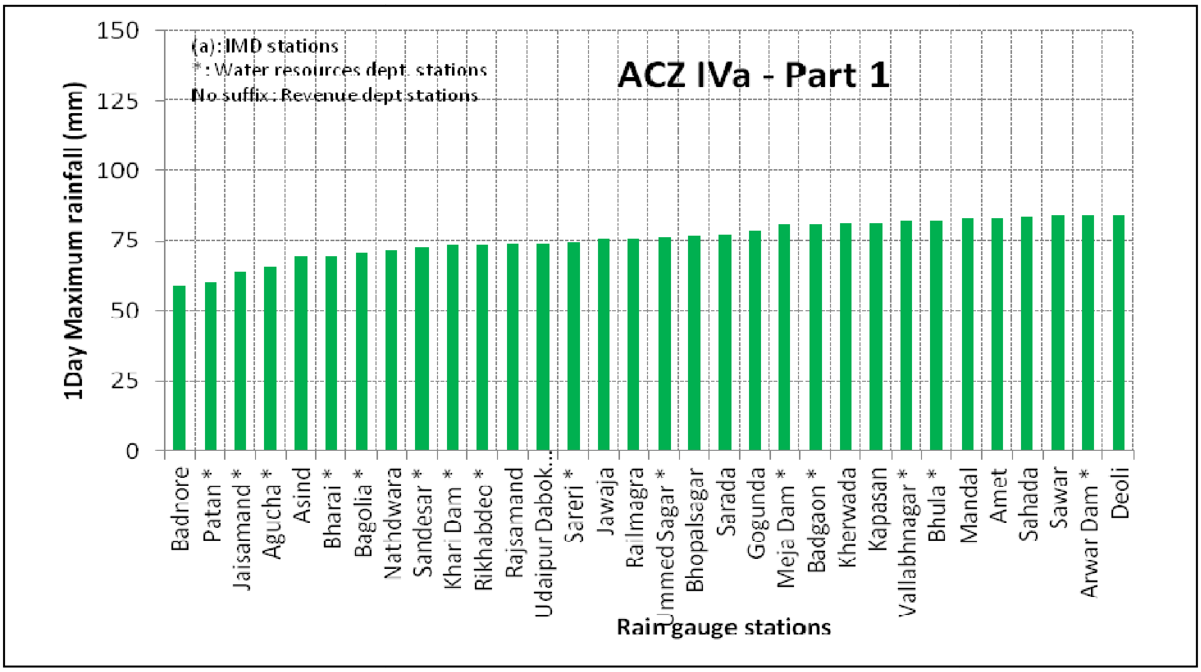
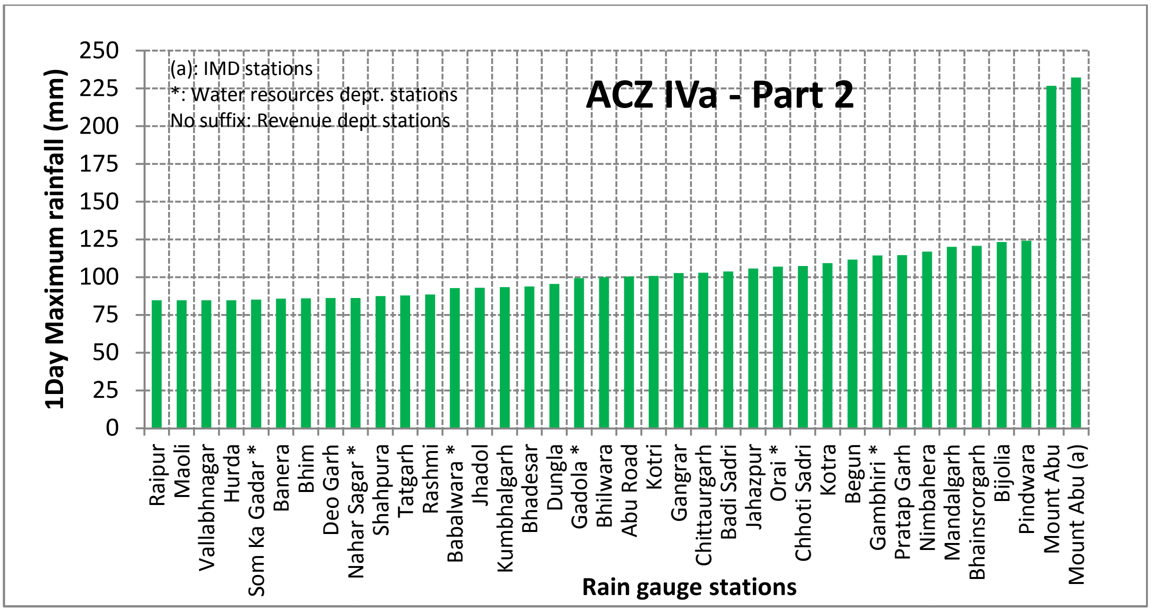
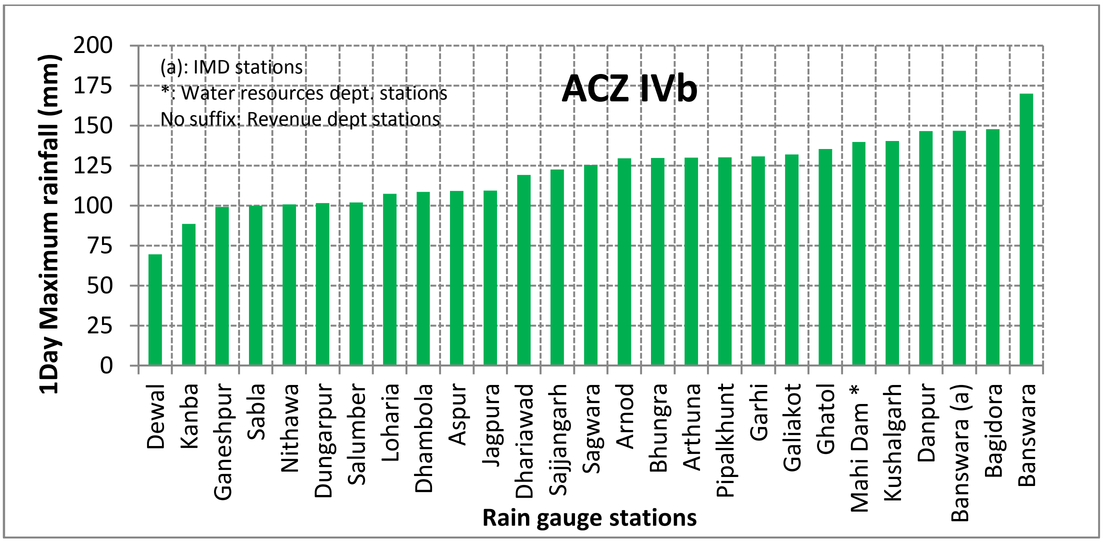


Figure 7.65 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IVa



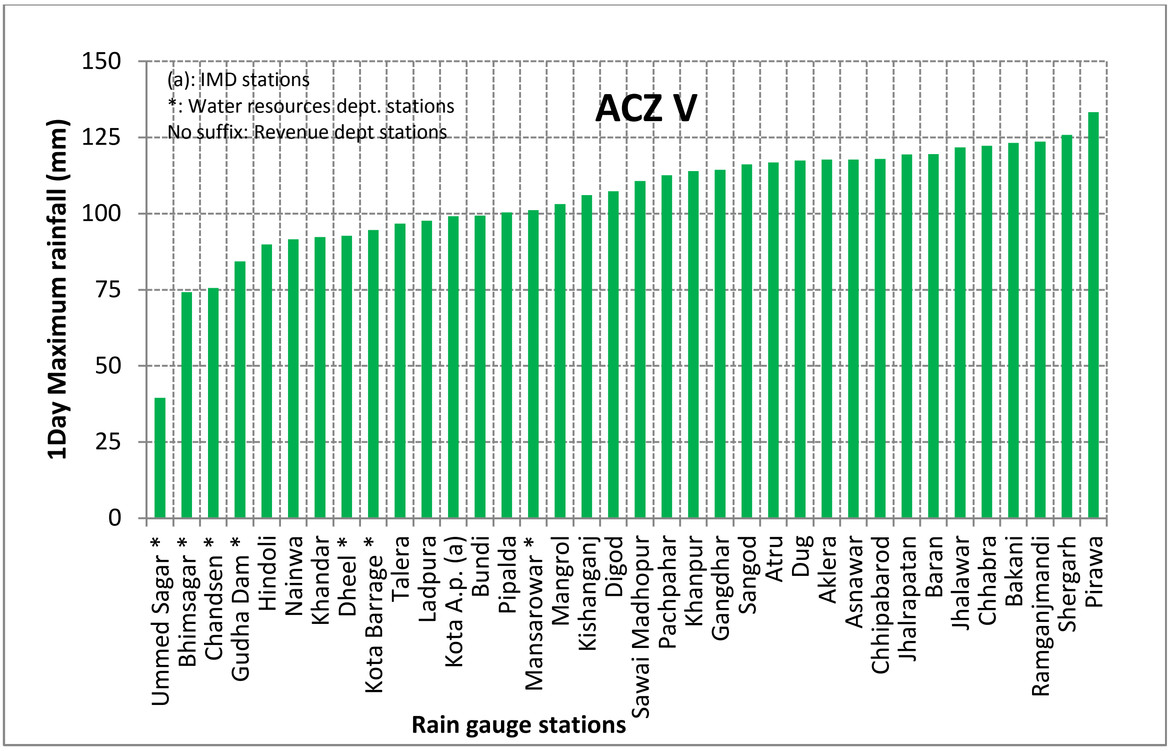
ACZ IVa received the highest mean 1-day maximum rainfall in station Mount Abu, with a value of 232.3 mm. Raingauge stations show high variability with respect to a highest mean 1-day maximum rainfall with a range of 84.8 to 232.3 mm. The stations Mount Abu and Mount Abu, falling under Sirohi District, receive the highest amount of rainfall in Rajasthan.

Figure 7.66 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ IVb



ACZ IVb has the highest mean 1-day maximum rainfall of 170 mm, observed at Station 266.

Figure 7.67 Mean 1-day Maximum Rainfall at Various Raingauge Stations in ACZ V



Raingauge stations falling under ACZ V also show high variability with respect to the mean 1-day maximum rainfall, with a highest mean 1-day maximum rainfall of 133.3 mm in station Pirawa, and the lowest value of 39.5 mm in Ummed Sagar station.

Various agroclimatic zones show large spatial variability with respect to maximum rainfall.

Table 7.44 shows the range of maximum rainfall within each agroclimatic zone.

Table 7.44 Spatial Variability of Maximum Rainfall within each Agroclimatic Zone, mm

ACZ	No. of stations	Range (1 Day)	Range (2 Day)	Range (3 Day)	Range (4 Day)	Range (5 Day)
Ia	10	125.0 - 337.0	155.0 - 472.0	167.5 - 561.0	165.0 - 569.0	166.2 - 494.5
Ib	18	68.3 - 232.0	107.9 - 280.9	125.1 - 358.7	93.0 - 377.0	63.0 - 279.0
Ic	9	102.0 - 233.0	120.0 - 433.0	136.2 - 433.0	116.6 - 274.5	120.0 - 289.5
IIa	19	125.0 - 457.2	217.0 - 529.1	271.5 - 571.3	274.0 - 554.0	211.0 - 634.0
IIb	33	113.0 - 620.0	185.0 - 940.0	185.0 - 1014.0	158.0 - 1052.0	160.0 - 1122.0
IIIa	52	156.0 - 589.2	178.0 - 840.0	193.0 - 919.4	174.0 - 935.0	198.6 - 949.6
IIIb	56	140.1 - 505.0	211.6 - 760.0	222.0 - 1030.0	171.7 - 1238.0	131.4 - 1251.0
IVa	71	127.0 - 700.0	170.0 - 976.2	189.3 - 1344.3	195.0 - 1437.0	183.3 - 1492.0
IVb	27	165.1 - 490.0	227.0 - 600.0	283.0 - 705.0	204.0 - 785.0	226.6 - 845.0
V	37	128.0 - 413.2	153.0 - 559.6	177.0 - 670.0	196.6 - 755.0	202.8 - 772.0

Source: WRD Daily Rainfall Data (1957-2010)

It is evident from Table 7.44 that for the 1-day maximum rainfall, the highest spatial variability (Spatial variability refers to range of values within a particular zone or area) is present in ACZ IVa, with values ranging from 127 to 700 mm, while the lowest spatial variability was found in ACZ Ic, with a range of 102 to 233 mm.

Maxima of maximum rainfall values (extreme rainfall events) within each agroclimatic zone are shown in Table 7.45. This table shows extreme rainfall events that occurred within each agroclimatic zone, along with the station, district and year of occurrence of the rainfall event.

Table 7.45 Agroclimatic Zone-Wise Maxima of Maximum Rainfall, mm

ACZ	Raingauge stations (WRIS code)	District	Station Name	1 day, mm	Year of occurrence
1 day					
Ia	354	Barmer	Balotra	337.0	1995
Ib	490	Ganganagar	Padampur	232.0	1978
Ic	446	Bikaner	Lunkaransar	233.0	2000
IIa	430	Nagaur	Nawa	457.2	1968
IIb	349	Barmer	Meli Tank *	360.7	1973
IIIa	186	Jaipur	Kanota *	589.2	1981
IIIb	192	Sawai Madhopur	Bamanwas	505.0	1981
IVa	332	Sirohi	Mount Abu	700.0	1992
IVb	269	Banswara	Garhi	490.0	2007
V	60	Baran	Baran	413.2	1967
2 day					
Ia	439	Barmer	Barmer	472.0	1990

ACZ	Raingauge stations (WRIS code)	District	Station Name	1 day, mm	Year of occurrence
Ib	507	Hanumangarh	T.A. Singh *	280.9	1961
Ic	446	Bikaner	Lunkaransar	433.0	2000
IIa	430	Nagaur	Nawa	529.1	1968
IIb	371	Pali	Hemawas*	550.0	1979
IIIa	181	Jaipur	Bassi	840.0	1981
IIIb	192	Sawai Madhopur	Bamanwas	760.0	1981
IVa	331	Sirohi	Mount Abu (a)	976.2	1973
IVb	266	Banswara	Banswara	600.0	1984
V	25	Jhalawar	Gangdhar	559.6	1983
3 day					
Ia	354	Barmer	Balotra	561.0	1990
Ib	507	Hanumangarh	T.A. Singh *	358.7	1959
Ic	446	Bikaner	Lunkaransar	433.0	2000
IIa	430	Nagaur	Nawa	571.3	1968
IIb	371	Pali	Hemawas*	750.0	1979
IIIa	186	Jaipur	Kanota *	919.4	1981
IIIb	192	Sawai Madhopur	Bamanwas	1,030.0	1981
IVa	331	Sirohi	Mount Abu (a)	1,344.0	1990
IVb	268	Banswara	Danpur	705.0	1986
V	120	Sawai Madhopur	Khandar	670.0	2005
4 Day					
Ia	354	Barmer	Balotra	569.0	1990
Ib	460	Hanumangarh	Bhadra	377.0	1978
Ic	456	Churu	Sujangarh	274.5	1975
IIa	339	Nagaur	Degana	554.0	1975
IIb	371	Pali	Hemawas*	810.0	1973
IIIa	186	Jaipur	Kanota *	935.0	1981
IIIb	192	Sawai Madhopur	Bamanwas	1,238.0	1981
IVa	332	Sirohi	Mount Abu	1,437.0	1990
IVb	268	Banswara	Danpur	785.0	1986
V	120	Sawai Madhopur	Khandar	755.0	2005
5 day					
Ia	520	Jodhpur	Jodhpur *	494.5	1990
Ib	466	Ganganagar	Dabla	279.0	2004
Ic	456	Churu	Sujangarh	289.5	1975
IIa	339	Nagaur	Degana	634.0	1975
IIb	363	Pali	Baniawas *	777.0	1980

ACZ	Raingauge stations (WRIS code)	District	Station Name	1 day, mm	Year of occurrence
IIIa	186	Jaipur	Kanota *	949.6	1981
IIIb	192	Sawai Madhopur	Bamanwas	1,251.0	1981
IVa	332	Sirohi	Mount Abu	1,492.0	1990
IVb	268	Banswara	Danpur	845.0	1986
V	120	Sawai Madhopur	Khandar	772.0	2005

(a): IMD stations, *: Water resources dept. Stations, No suffix: Revenue Dept. Stations

Source: WRD Daily Rainfall Data (1957-2010)

It is evident from Table 7.45 that the highest magnitude of 1-day maximum rainfall in ACZ Ia is 337mm (in 1995), occurred in Balotra raingauge station in Barmer District. ACZ Ib received a 1-day maximum rainfall of 232 mm in Padampur station in Ganganagar District in 1978. Lunkaransar station in Bikaner District in ACZ Ic received a maximum 1-day rainfall of 233 mm in 2000.

ACZs IIa and IIb received a 1-day maximum rainfall of 457 mm (in 1968) and 360 mm (in 1973) in Nagaur and Barmer Districts, respectively.

The maximum of 1-day maximum rainfall in ACZs IIIa and IIIb occurred in Kanota and Bamanwas raingauge stations, with values of 589.2 and 505 mm (in 1981), respectively.

ACZ IVa received the highest value of 1-day maximum rainfall among all the agroclimatic zones - 700 mm. This rainfall was recorded in Mount Abu raingauge station in Sirohi District in 1992. In ACZ IVb the maximum of 1-day maximum rainfall was observed in Garhi raingauge station, in Banswara District, with a value of 490 mm in 2007, whereas in ACZ V it was 413.2 mm, recorded in Baran raingauge station of Baran District in 1967.

ACZ-wise details of 2-day, 3-day, 4-day and 5-day maxima of maximum rainfall are shown in Table 7.45 above.

7.17 ACZ-wise Evaporation Statistics

Table 7.46 shows the mean annual total evaporation and its ranges within the various ACZs. There are some ACZs which do not have any observation station within the Zone. Mean values for such zones are evaluated by the GIS-overlay technique on the respective raster grids and are presented in Table 7.46 where ACZ boundary polygons are overlaid on raster grids which are generated with available observed dataset and mean values are extracted from zonal statistics.

It is evident from table 7.46 that Highest Mean Annual total evaporation is observed in ACZ Ic, Hyper Arid Irrigated Western Plain Partially, while it is lowest in ACZ Ib, Irrigated North Western Plain.

Table 7.46 Mean Annual Total Evaporation in Various Agroclimatic Zones, cm

Agro-climatic Zone		Min.	Max.	Variation	Mean	CV*
Ia	Arid Western	206.9	264.4	57.5	232.9	0.06
Ib	Irrigated North Western Plain	174.1	222.7	48.6	194.3	0.06
Ic	Hyper Arid Irrigated Western Plain Partially	199.7	306.7	107.0	247.5	0.11
IIa	Transitional Plain of inland drainage	199.3	242.0	42.7	214.1	0.05
IIb	Transitional Plain of Luni Basin	141.1	251.4	110.3	199.0	0.13
IIIa	Semi-Arid Eastern Plain	205.8	228.1	22.3	218.3	0.03
IIIb	Flood Prone Eastern Plain	209.4	224.0	14.5	216.7	0.01
IVa	Sub humid Southern Plain	148.8	217.5	68.7	197.9	0.05
IVb	Humid southern Plain	201.2	222.9	21.7	214.3	0.03
V	Humid South-Eastern Plain	189.5	218.3	28.7	206.6	0.02

* CV - Coefficient of Variation

Table 7.47 Agroclimatic Zone-wise Total Annual and Mean Monthly Evaporation, cm

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
1990	263.9	215.6	265.8	221.2	138.3	NA	NA	195.2	NA	202.2
1991	266.9	213.8	273.9	NA	114.6	NA	NA	199.6	NA	NA
1992	261.6	187.1	215.9	NA	132.5	213.2	NA	213.5	246.0	NA
1993	269.5	209.2	243.2	NA	146.2	245.1	NA	212.0	240.4	NA
1994	243.0	195.2	229.3	NA	137.5	248.5	NA	190.4	207.8	NA
1995	NA	NA	234.7	NA	150.0	226.8	NA	207.8	238.4	186.1
1996	254.5	NA	231.9	NA	156.4	NA	NA	202.6	233.9	NA
1997	192.8	166.6	292.7	193.8	121.7	208.3	NA	173.0	206.1	198.7
1998	212.8	181.4	415.6	203.2	145.5	210.3	NA	191.0	190.2	217.6
1999	199.1	185.2	449.9	241.0	168.5	238.4	NA	162.4	212.4	234.6
2000	212.9	188.7	285.9	240.2	NA	224.6	NA	221.8	NA	NA
2001	231.7	163.3	283.9	195.6	NA	212.9	NA	204.4	NA	201.1
2002	286.3	200.1	318.4	223.6	NA	257.5	NA	226.3	NA	241.2
2003	215.9	161.1	235.7	164.1	NA	214.2	NA	207.6	215.1	224.6
2004	213.0	171.3	284.4	194.7	NA	233.1	NA	192.8	235.5	NA
2005	229.9	164.6	268.2	195.1	NA	235.3	NA	193.0	226.2	NA
2006	203.2	146.7	244.9	182.4	NA	224.8	NA	176.6	NA	NA
2007	228.7	73.8	255.8	194.1	NA	NA	NA	165.1	NA	NA
2008	193.5	155.2	236.3	174.0	NA	NA	NA	NA	NA	NA
2009	235.5	155.2	241.2	167.1	NA	NA	NA	NA	NA	NA
Positive (P) or Negative (N) trend	N	N	N	N	P	P	NA	N	N	P
Confidence Level, %	79.8#	100.0	27.4#	99.3	89.3#	17.3#	NA	87.3#	24.6#	89.2#

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Month	Evaporation, cm									
January	11.0	4.7	9.8	6.7	5.1	8.3	NA	8.7	10.2	8.4
February	12.9	6.8	12.6	9.1	6.8	11.7	NA	11.2	11.2	10.6
March	20.3	12.8	22.8	17.1	12.8	19.7	NA	18.8	17.8	20.5
April	26.8	20.4	32.5	26.0	17.9	27.4	NA	26.5	25.6	30.0
May	33.6	28.3	39.4	32.2	26.7	36.7	NA	33.9	37.7	40.1
June	30.2	26.1	36.0	27.5	21.2	34.1	NA	27.6	34.5	33.5
July	23.6	20.7	30.8	21.0	13.3	20.2	NA	15.4	21.7	20.0
August	18.0	19.4	26.5	19.4	10.7	15.4	NA	10.9	13.2	12.7
September	18.3	15.6	24.6	17.9	9.8	17.6	NA	12.3	13.6	14.2
October	18.9	12.7	20.8	15.0	9.1	17.1	NA	13.4	14.0	14.8
November	14.3	7.2	13.2	9.2	5.6	11.6	NA	10.4	12.3	10.9
December	11.2	4.8	9.0	6.3	4.3	8.9	NA	8.2	11.0	8.3
Total	239.1	179.5	278.0	207.4	143.3	228.7	NA	197.3	222.8	224.0
Mean Monthly	19.9	15.0	23.1	17.3	11.9	19.1	NA	16.4	18.6	18.7

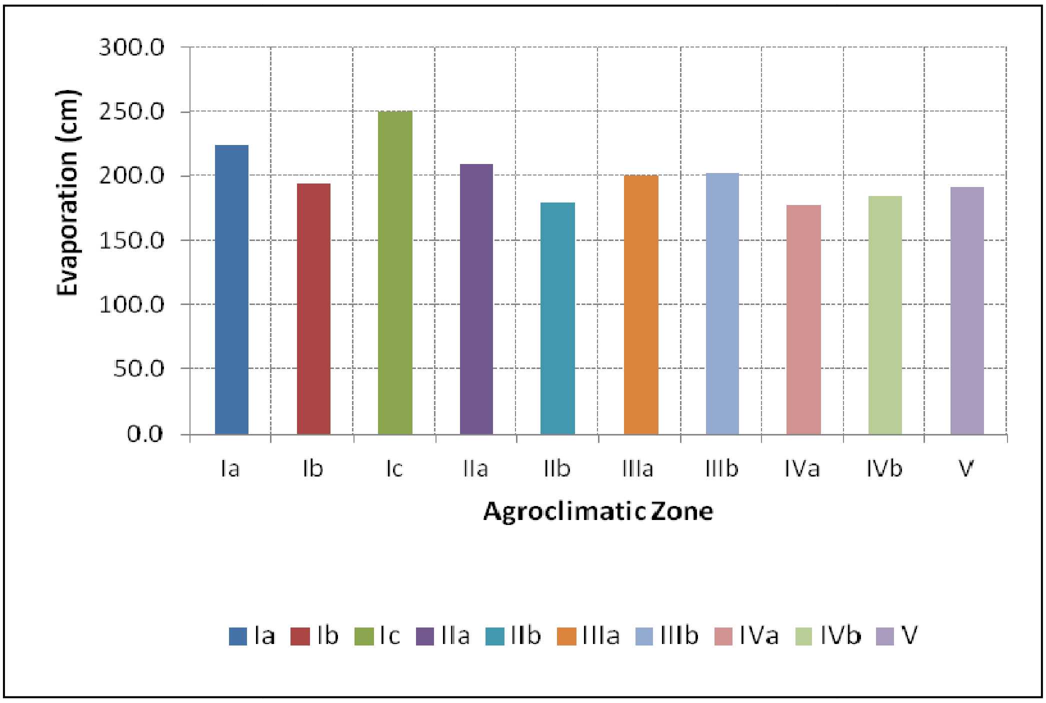
Source: IMD monthly dataset (1990-2009)
# indicates insignificant trend as the confidence level is less than 90%.
NA - Data Not Available

Table 7.47 shows evaporation trends within the ACZs for the study period of 20 years (1990 to 2009), along with mean monthly evaporation values.

In ACZs Ib and IIa the analysis shows that the trend is significantly decreasing, with a confidence level greater than 90%. For ACZs IIIb data is not available while for the rest of ACZs the trend is statistically insignificant.

Figure 7.68 shows ACZ-wise mean annual evaporation as evaluated by interpolation using available IMD stations data where ACZ boundary polygons are overlaid on raster grids generated with available dataset and mean values are extracted from zonal statistics.

Figure 7.68 Agroclimatic Zone-Wise Mean Annual Evaporation Data, cm



District-wise monthly evaporation values were derived from the respective monthly evaporation raster grids, where district boundaries have been overlaid on raster grid and summarized in each district boundary to calculate mean values within each district. With a similar procedure Block wise evaporation was also computed and is presented in Appendix 11 (Volume 2 of this report). District-wise monthly evaporation values are presented in Table 7.48.

Highest mean monthly evaporation at the district level is observed in Jaisalmer District, 23.1 cm, while it is lowest in Sirohi District, 14.4 cm.

Table 7.48 District-Wise Mean Monthly Evaporation, cm

District	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Monthly Mean	Annual
Ajmer	8.4	11.0	19.1	26.9	35.5	31.0	19.6	14.7	15.3	10.9	8.4	15.5	18.0	216.3
Alwar	7.9	10.8	18.7	26.7	35.2	31.5	20.3	16.0	15.7	10.7	8.0	16.7	18.2	218.4
Banswara	10.0	11.1	17.9	25.7	37.3	33.8	21.3	13.2	14.0	12.1	10.7	13.6	18.4	220.7
Baran	8.6	10.9	19.3	27.5	36.6	31.1	18.5	12.6	14.5	10.9	8.5	13.9	17.7	212.9
Barmer	10.3	12.0	18.7	24.9	31.3	28.2	23.1	18.2	18.6	13.7	10.5	18.6	19.0	228.1
Bharatpur	8.1	10.9	18.8	26.8	35.4	31.3	19.9	15.4	15.5	10.7	8.1	16.1	18.1	217.0
Bhilwara	8.5	10.8	18.8	26.4	35.0	29.7	18.1	12.9	14.2	10.6	8.3	13.8	17.3	207.1
Bikaner	7.8	10.3	18.8	27.2	34.9	31.9	24.9	21.3	17.2	11.0	7.5	20.0	19.4	232.8
Bundi	8.6	10.9	19.6	27.9	37.1	31.4	18.5	12.3	14.5	10.9	8.4	13.7	17.8	213.8
Chittaurgarh	8.7	10.9	18.5	26.1	34.5	29.0	17.0	11.9	13.7	10.5	8.4	13.0	16.8	202.2
Churu	7.0	9.5	17.6	26.2	33.1	28.9	21.7	19.3	15.4	9.7	6.7	18.0	17.8	213.1
Dausa	8.2	11.3	19.3	27.1	36.1	32.6	20.0	15.3	16.2	11.1	8.5	16.7	18.5	222.3
Dhaulpur	8.5	11.1	18.8	26.8	35.6	31.2	19.6	14.8	15.2	10.7	8.2	15.6	18.0	216.1
Dungarpur	9.2	10.8	18.1	26.0	36.0	31.4	19.6	13.1	13.9	11.2	9.4	13.6	17.7	212.4
Ganganagar	5.9	8.2	15.2	23.1	30.8	28.1	22.0	19.8	14.3	8.6	5.9	17.1	16.6	198.9
Hanumangarh	6.2	8.5	15.8	23.9	31.4	28.1	21.5	19.3	14.5	8.9	6.1	17.1	16.8	201.3
Jaipur	8.2	11.4	19.4	27.2	36.2	33.0	20.2	15.6	16.5	11.2	8.6	17.2	18.7	224.6
Jaisalmer	10.8	13.4	23.2	32.4	38.8	34.7	29.7	25.1	21.0	14.0	10.1	23.6	23.1	276.8
Jalore	8.3	10.1	17.1	23.5	31.2	26.7	19.0	14.8	14.5	10.4	8.0	14.7	16.5	198.4
Jhalawar	8.8	11.0	19.0	26.8	35.8	30.4	17.9	12.0	14.2	10.9	8.6	13.3	17.4	208.7
Jhunjhunu	7.1	9.7	17.8	26.3	33.4	29.1	21.1	18.4	15.4	9.8	6.9	17.6	17.7	212.8
Jodhpur	10.0	12.5	21.5	29.6	37.4	33.0	24.2	19.2	17.6	12.4	9.4	18.4	20.4	245.2

District	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Monthly Mean	Annual
Karauli	8.4	11.2	19.1	27.1	35.9	31.8	19.6	14.7	15.5	10.9	8.3	15.8	18.2	218.2
Kota	8.6	10.9	19.6	28.1	37.4	31.4	18.4	12.1	14.4	10.9	8.4	13.6	17.8	213.9
Nagaur	8.4	11.0	19.4	27.5	35.5	31.4	22.1	17.9	16.3	11.0	8.1	17.6	18.8	226.1
Pali	8.0	10.2	18.0	25.1	33.5	28.3	18.7	14.4	13.8	9.7	7.5	14.1	16.8	201.4
Pratapgarh	9.4	11.0	18.2	26.0	36.2	31.8	19.7	12.8	13.9	11.4	9.6	13.5	17.8	213.5
Rajsamand	7.9	10.1	17.9	25.5	33.6	27.8	17.3	13.0	13.3	9.5	7.5	13.4	16.4	196.9
Sawai Madhopur	8.4	11.1	19.3	27.3	36.3	32.0	19.4	14.3	15.5	11.0	8.5	15.6	18.2	218.7
Sikar	7.5	10.2	18.2	26.6	34.2	30.2	20.8	17.6	15.7	10.2	7.4	17.4	18.0	216.1
Sirohi	6.7	8.5	15.4	21.6	30.0	24.6	15.8	12.3	11.6	7.9	6.1	12.0	14.4	172.4
Tonk	8.4	11.2	19.4	27.3	36.3	32.0	19.4	14.2	15.6	11.1	8.5	15.6	18.2	218.9
Udaipur	8.2	10.4	18.3	26.4	34.5	28.1	17.1	12.5	13.3	9.7	7.7	13.2	16.6	199.2

Source: IMD monthly dataset (1990-2009)

7.18 Agroclimatic Zone-wise Wind Speed

From Table 7.49 it can be seen that the mean wind speed is highest in ACZ Ic (Hyper Arid Irrigated Western Plain Partially), with 6.5 km/hr, and lowest in ACZ IIb (Transitional Plain of Luni Basin), with 3.8 km/hr.

Table 7.49 Agroclimatic Zone-Wise Mean Annual Daily Wind Speed Statistics, km/hr

Agro-climatic Zone		Min.	Max.	Variation	Mean	CV*
Ia	Arid Western	3.3	8.1	4.8	5.2	0.24
Ib	Irrigated North Western Plain	3.2	5.3	2.1	4.1	0.12
Ic	Hyper Arid Irrigated Western Plain Partially	4.4	10.1	5.7	6.5	0.23
IIa	Transitional Plain of inland drainage	3.6	6.1	2.5	4.7	0.11
IIb	Transitional Plain of Luni Basin	1.9	5.5	3.6	3.8	0.22
IIIa	Semi-Arid Eastern Plain	1.6	7.6	6.0	5.3	0.19
IIIb	Flood Prone Eastern Plain	2.0	6.1	4.1	4.4	0.14
IVa	Sub humid Southern Plain	2.3	8.5	6.2	4.8	0.25
IVb	Humid southern Plain	4.6	7.2	2.7	5.1	0.08
V	Humid South-Eastern Plain	1.4	6.5	5.1	4.3	0.24

* CV - Coefficient of Variation

From Table 7.50 below it can be seen that all agroclimatic zones attain maximum wind speed during June, and lowest in the months of November and December.

As evident from Table 7.50 there is a significantly decreasing trend in ACZ Ia & Ib, with greater than 90 % confidence level. In the rest of the ACZs the trend is statistically insignificant.

Table 7.50 Agroclimatic Zone-Wise Mean Annual Daily Wind Speed, Trends and Mean Monthly values, km/hr

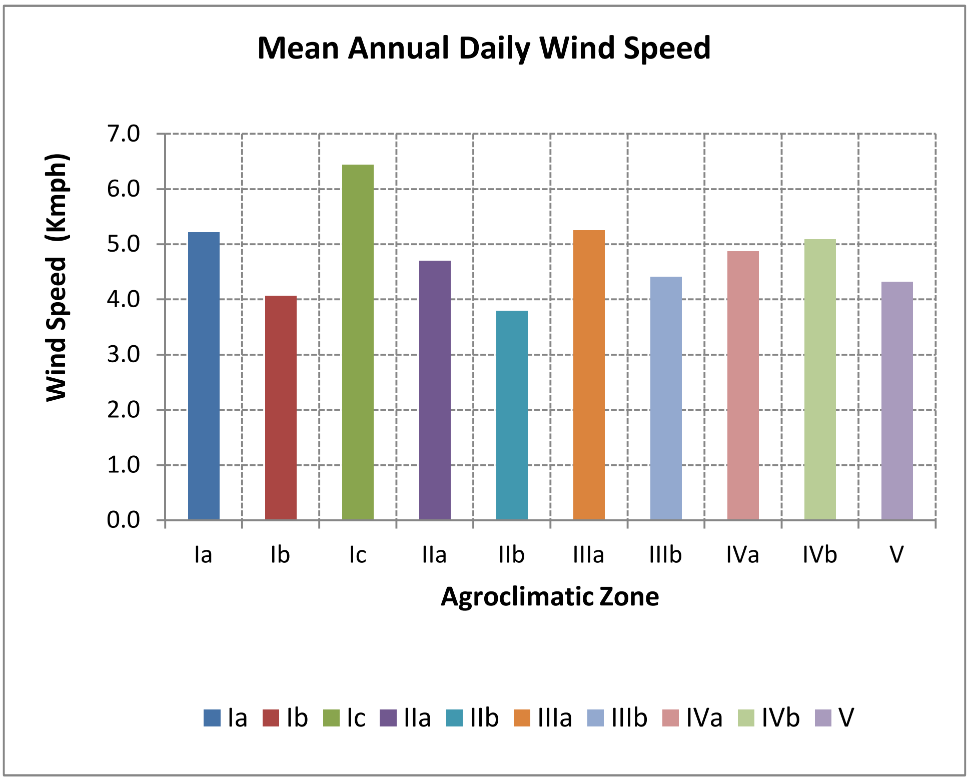
ACZ / Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
1990	9.2	4.9	5.2	3.3	2.9	6.5	NA	5.8	NA	5.6
1991	6.9	4.2	5.2	4.8	2.1	5.7	NA	5.8	NA	4.7
1992	6.3	4.0	4.9	4.7	2.3	5.5	NA	6.4	NA	4.6
1993	6.2	3.6	5.0	4.2	2.3	5.9	NA	6.3	NA	3.8
1994	6.7	3.9	4.6	4.1	1.7	5.3	NA	5.6	NA	4.1
1995	7.4	3.4	4.4	3.7	2.5	4.6	NA	5.8	NA	3.8
1996	5.0	3.3	4.0	3.4	2.8	4.6	NA	6.1	NA	3.8
1997	4.5	3.1	8.4	3.0	2.9	6.5	NA	6.4	NA	4.0
1998	3.6	3.0	8.6	2.9	1.5	5.2	NA	6.2	NA	3.9
1999	5.8	3.6	10.0	3.8	2.2	4.4	NA	6.1	NA	3.8
2000	5.3	4.1	10.7	4.3	2.1	4.6	NA	5.9	NA	4.1
2001	4.5	2.8	8.2	3.8	2.2	2.5	NA	NA	NA	4.0

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
2002	5.4	2.8	9.9	5.1	NA	5.4	NA	6.2	NA	5.6
2003	4.3	2.8	9.0	4.3	2.7	6.3	NA	8.6	NA	4.9
2004	5.1	2.8	10.6	6.2	2.4	7.1	NA	8.7	NA	5.5
2005	4.6	2.7	8.7	4.1	2.2	7.7	NA	5.3	NA	3.6
2006	4.4	3.0	7.9	4.0	2.4	7.7	NA	3.8	NA	3.8
2007	4.1	2.2	7.0	3.5	2.2	7.1	NA	3.5	NA	3.6
2008	4.4	2.6	7.7	3.2	0.9	8.7	NA	4.2	NA	3.5
2009	4.7	2.1	7.2	3.5	1.6	8.1	NA	4.9	NA	3.5
Positive(P) or Negative(N) trend	N	N	P	N	N	P	NA	N	NA	N
Confidence Level, %	97.0	100.0	59.9#	67.3#	63.6#	89.2#	NA	65.7#	NA	57.9#
ACZ Month	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
January	4.7	1.8	4.3	2.4	1.6	3.2	NA	3.5	NA	2.8
February	5.1	3.0	5.3	3.1	2.1	4.3	NA	4.1	NA	3.3
March	5.3	3.3	6.1	3.6	2.5	5.5	NA	5.3	NA	3.7
April	5.9	3.9	7.9	4.4	2.3	7.0	NA	6.6	NA	4.2
May	7.9	5.0	11.6	6.3	3.6	9.9	NA	9.2	NA	5.4
June	8.5	5.3	13.0	6.3	3.9	10.4	NA	9.6	NA	5.8
July	7.0	5.2	12.1	5.7	3.1	9.0	NA	8.3	NA	5.3
August	6.4	4.6	10.7	4.7	2.5	8.2	NA	6.3	NA	4.7
September	5.5	3.5	8.5	4.1	2.3	6.9	NA	4.8	NA	3.8
October	3.8	1.6	4.3	2.4	1.5	3.4	NA	2.9	NA	2.8
November	3.6	0.9	3.3	1.8	1.1	2.3	NA	2.2	NA	2.4
December	4.0	1.0	3.3	1.7	1.2	2.1	NA	2.5	NA	2.4
Mean monthly	4.7	1.8	4.3	2.4	1.6	3.2	NA	3.5	NA	2.8

Source: IMD Monthly dataset (1990-2009)
# indicates insignificant trend as the confidence level is less than 90%.
NA- Data not available

Figure 7.69 below shows ACZ-wise mean annual daily wind speeds, computed by interpolation, using available IMD stations data, , where ACZ boundary polygons are overlaid on raster grids which are generated with available observed dataset and mean values are extracted from zonal statistics.

Figure 7.69 Agroclimatic Zone-Wise Annual Mean Daily Wind Speeds, km/hr



7.19 Agroclimatic Zone-wise Sunshine Hours

From Table 7.51 it may be observed that the maximum of mean daily sunshine hours occurs in ACZs Ia, Ic and IIb, with 8.4 hours/day, and the minimum - in ACZ Ib, Irrigated North-Western Plain, with 7.6 hours/day.

There are some ACZs within which there are no observation stations available. For such ACZs statistics were evaluated using GIS interpolation techniques with IMD monthly weather dataset, where ACZ boundary polygons are overlaid on raster grids which are generated with available observed dataset and mean values are extracted from zonal statistics.

Table 7.51 Agroclimatic Zone-Wise Mean Annual Daily Sunshine Hours Statistics

Agro-Climatic Zone		Min. hrs/day	Max. hrs/day	Variation	Mean, hrs/day	CV*
Ia	Arid Western	8.30	8.60	0.30	8.40	0.01
Ib	Irrigated North Western Plain	7.40	8.00	0.60	7.60	0.02
Ic	Hyper Arid Irrigated Western Plain, Partially	7.60	8.80	1.20	8.40	0.04
IIa	Transitional Plain of Inland Drainage	7.70	8.40	0.70	8.10	0.02
IIb	Transitional Plain of Luni Basin	8.20	8.50	0.30	8.40	0.00
IIIa	Semi-Arid Eastern Plain	7.90	8.30	0.40	8.00	0.01
IIIb	Flood Prone Eastern Plain	7.90	8.00	0.10	8.00	0.00
IVa	Sub humid Southern Plain	8.00	8.40	0.30	8.30	0.01

Agro-Climatic Zone		Min. hrs/day	Max. hrs/day	Variation	Mean, hrs/day	CV*
IVb	Humid southern Plain	8.20	8.30	0.10	8.30	0.00
V	Humid South-Eastern Plain	7.90	8.20	0.30	8.10	0.01

* CV - Coefficient of Variation

It may be observed from Table 7.52 that in ACZs Ib and Ic the trend is significantly decreasing, with greater than 90 % confidence level, while for the rest of the ACZs the trend is statistically insignificant.

Sunshine hours data are not available for all the agroclimatic zones; therefore the presented annual data summary is for only those zones whose data are available. For the rest of the ACZ's the statistics were evaluated using GIS interpolation techniques, where ACZ boundary polygons are overlaid on raster grids which are generated with available observed dataset and mean values are extracted from zonal statistics.

It is also evident from Table 7.52 that the number of sunshine hours per day is maximum in April and May and minimum in July and August.

Table 7.52 Agroclimatic Zone-wise Trend and Mean Monthly Sunshine Hours, hours/day

Year \ ACZ	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Annually										
1990	8.6	7.9	9.3	NA	NA	8.1	NA	NA	NA	NA
1991	8.5	NA	9.2	NA	NA	NA	NA	NA	NA	NA
1992	NA	7.4	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	8.1	NA	NA	NA	8.1	NA	NA	NA	NA
1994	NA	7.4	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	7.7	NA	NA	NA	NA
1996	8.6	NA	NA	NA	NA	7.4	NA	NA	NA	NA
1997	8.7	7.1	9.0	NA	NA	NA	NA	NA	NA	NA
1998	8.6	7.7	9.0	NA	NA	NA	NA	NA	NA	NA
1999	8.7	7.7	9.1	NA	NA	9.3	NA	NA	NA	NA
2000	8.5	7.3	8.9	NA	NA	NA	NA	NA	NA	NA
2001	8.3	7.3	8.7	NA	NA	NA	NA	NA	NA	NA
2002	8.2	7.2	8.5	NA	NA	8.1	NA	NA	NA	NA
2003	7.8	6.9	8.2	NA	NA	7.5	NA	NA	NA	NA
2004	8.1	6.7	8.3	NA	NA	8.0	NA	NA	NA	NA
2005	8.5	7.4	9.0	NA	NA	7.9	NA	NA	NA	NA
2006	8.1	7.1	8.2	NA	NA	7.6	NA	NA	NA	NA
2007	8.7	7.7	8.9	NA	NA	7.8	NA	NA	NA	NA
2008	8.0	7.3	8.5	NA	NA	7.6	NA	NA	NA	NA
2009	8.8	7.7	8.6	NA	NA	8.1	NA	NA	NA	NA
Positive (P) or Negative (N) trend	N	N	N	NA	NA	N	NA	NA	NA	NA

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Confidence Level, %	68.0#	>99.0	96.0	NA	NA	54.0#	NA	NA	NA	NA
Monthly										
Month	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
January	8.3	5.7	8.4	NA	NA	8.0	NA	NA	NA	NA
February	8.9	7.1	8.7	NA	NA	8.5	NA	NA	NA	NA
March	8.8	7.7	8.8	NA	NA	8.1	NA	NA	NA	NA
April	9.5	8.4	9.4	NA	NA	9.3	NA	NA	NA	NA
May	9.8	8.4	9.6	NA	NA	9.2	NA	NA	NA	NA
June	8.3	7.5	8.8	NA	NA	7.9	NA	NA	NA	NA
July	6.6	6.8	7.7	NA	NA	5.4	NA	NA	NA	NA
August	6.7	8.0	8.0	NA	NA	5.2	NA	NA	NA	NA
September	8.2	7.8	8.9	NA	NA	7.2	NA	NA	NA	NA
October	9.1	8.0	9.4	NA	NA	8.9	NA	NA	NA	NA
November	8.6	7.4	9.1	NA	NA	8.6	NA	NA	NA	NA
December	7.7	6.0	8.3	NA	NA	7.4	NA	NA	NA	NA
Mean Monthly	8.4	7.4	8.8	NA	NA	7.8	NA	NA	NA	NA

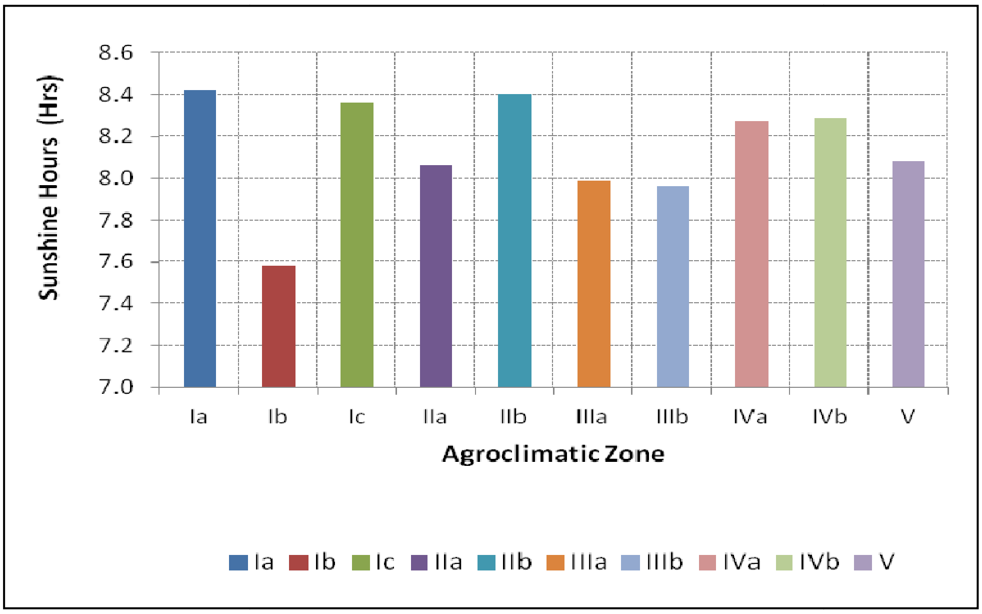
Source: IMD monthly dataset (1990-2009)

# indicates insignificant trend, as the confidence level is less than 90%.

NA- Data not available

Figure 7.70 shows ACZ-wise mean annual daily sunshine hours as evaluated by interpolation of available IMD stations data.

Figure 7.70 Agroclimatic Zone-wise Mean annual Daily Sunshine Hours, Hours/day



7.20 Agroclimatic Zone-wise Relative Humidity (RH)

Table 7.53 shows ACZ-wise relative humidity statistics. It is evident from this table that the highest mean annual daily relative humidity is observed in ACZ Ib and ACZ IVb (53.3%) while it is lowest in ACZ Ic (46.9%)

Table 7.53 Agroclimatic Zone-Wise Mean Annual Daily Relative Humidity Data, %

ACZ		Min.	Max.	Variation	Mean	CV*
Ia	Arid Western	43.9	52.3	8.4	47.4	0.04
Ib	Irrigated North Western Plain	46.9	57.7	10.8	52.9	0.05
Ic	Hyper Arid Irrigated Western Plain Partially	43.5	50.7	7.2	46.9	0.03
IIa	Transitional Plain of inland drainage	43.8	55.6	11.8	48.8	0.06
IIb	Transitional Plain of Luni Basin	44.7	61.4	16.7	52.0	0.07
IIIa	Semi Arid Eastern Plain	43.5	53.7	10.2	48.5	0.04
IIIb	Flood Prone Eastern Plain	49.4	55.9	6.5	52.5	0.03
IVa	Sub humid Southern Plain	47.1	61.5	14.4	52.5	0.04
IVb	Humid southern Plain	51.5	54.2	2.7	53.3	0.01
V	Humid South-Eastern Plain	44.1	55.1	11.0	51.2	0.04

* CV - Coefficient of Variation

From Table 7.54 it is evident that in ACZs Ia and IIb, there is a significantly decreasing trend, with a confidence level greater than 90%, while ACZs IIIb shows significantly increasing trends. In the rest of the ACZs the trend is statistically insignificant.

Except for Zone Ib, where relative humidity attains a maximum value in January, in the rest of the zones the maximum value of relative humidity is attained in August.

Figure 7.71 shows comparative ACZ-wise RH values. The Lowest mean relative humidity is observed in ACZ Ic, Hyper Arid Irrigated Western Plain, partially, while the highest occurs in ACZs IVb.

Table 7.54 Agroclimatic Zone-Wise Annual Daily Relative Humidity Trends and Mean Monthly Relative Humidity, %

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
1990	51.7	53.9	45.1	51.5	56.1	48.9	49.5	56.9	55.1	49.7
1991	46.3	52.7	43.1	49.4	55.0	44.3	47.6	52.8	50.2	46.0
1992	51.6	55.1	46.7	48.8	60.4	46.1	52.9	51.7	50.2	48.3
1993	46.9	51.8	44.0	52.7	57.6	45.8	52.0	53.0	51.6	50.6
1994	49.0	54.4	46.8	54.3	60.2	47.4	50.7	54.5	55.0	50.2
1995	47.4	55.6	44.6	52.4	58.2	45.9	51.1	54.1	52.0	49.3
1996	47.1	57.9	45.7	54.2	58.1	47.8	49.3	53.7	52.3	50.4
1997	51.7	62.6	49.9	58.1	62.1	53.5	61.6	59.9	57.4	60.4
1998	50.6	62.0	46.8	55.5	58.4	49.3	58.5	55.9	55.5	55.2
1999	41.0	58.0	45.4	49.0	48.4	45.6	54.1	55.3	57.9	53.3
2000	41.5	56.3	43.9	49.3	49.7	42.8	NA	51.8	54.2	50.0
2001	41.4	58.5	44.0	54.3	64.5	44.0	NA	67.9	50.3	57.5
2002	41.2	61.0	42.2	46.6	NA	41.1	56.8	49.5	48.7	47.1
2003	44.9	60.3	46.4	53.1	51.7	48.1	59.3	57.4	55.2	48.3
2004	43.3	55.6	45.0	45.2	59.4	44.5	63.5	49.4	55.1	51.1
2005	42.7	58.1	46.6	50.8	44.7	43.9	61.0	55.4	52.3	52.0
2006	42.0	60.7	46.7	53.8	50.2	45.2	60.0	56.5	57.0	53.5
2007	44.1	61.4	44.9	52.2	53.4	45.1	59.0	55.5	52.8	51.2
2008	44.2	59.6	43.5	52.4	53.1	44.8	63.2	55.9	50.9	49.2
2009	41.8	57.5	41.2	44.0	47.1	41.2	NA	50.4	58.8	51.5
	N	P	N	N	N	N	P	P	P	P

ACZ Year	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Positive(P) or Negative(N) trend	N	P	N	N	N	N	P	P	P	P
Confidence Level, %	95.8	81.6#	70.6#	54.5#	93.6	83.8#	99.4	25.5#	83.8#	55.9#
ACZ Month	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
January	47.0	72.9	49.5	62.8	53.6	48.8	64.3	55.2	49.6	56.8
February	42.1	66.9	44.8	56.8	47.0	42.8	55.2	47.4	40.9	48.1
March	34.6	57.6	35.0	45.1	42.6	31.2	46.6	36.8	32.4	35.4
April	30.8	37.7	29.7	31.7	38.3	23.6	33.6	29.8	31.2	26.6
May	37.6	34.0	35.2	33.7	45.4	28.3	33.8	35.5	41.2	29.7
June	46.6	44.4	45.0	46.0	55.0	43.9	45.8	54.0	56.3	45.0
July	60.0	60.1	58.7	62.9	70.5	66.8	70.5	77.3	76.2	69.2
August	64.5	63.1	61.6	67.5	74.4	72.3	77.4	82.3	81.4	75.9
September	55.8	61.2	55.3	60.9	67.1	60.4	73.0	73.5	74.6	67.1
October	40.3	56.6	39.5	47.6	53.4	40.8	55.9	54.1	55.0	50.0
November	40.5	63.0	39.3	51.6	53.3	42.1	55.5	52.6	48.7	49.9
December	45.2	72.1	48.0	60.4	55.9	49.6	62.7	56.4	52.1	56.6
Mean Monthly	45.4	57.5	45.1	52.2	54.7	45.9	56.2	54.6	53.3	50.8

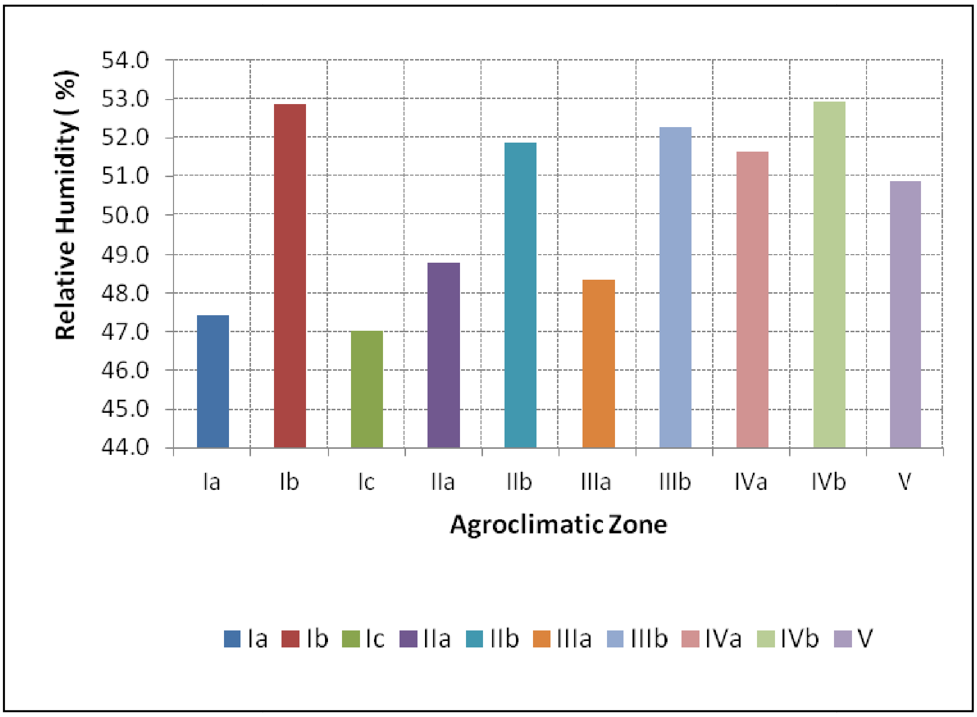
Source: IMD monthly dataset (1990-2009).

# indicates insignificant trend, with confidence level less than 90%

NA- Data not available

Figure 7.71 shows agroclimatic zone-wise mean annual daily relative humidity, as evaluated by interpolation using available IMD stations data.

Figure 7.71 Agroclimatic Zone-Wise Mean Annual Daily Relative Humidity, %



Agroclimatic Zone-wise weather parameter maps are presented in Volume 3 of this report.

7.21 Agroclimatic Zone-wise Evapotranspiration

There are no observations on actual evapotranspiration (ET) available in Rajasthan, which is usually measured with lysemeters. However, it is possible to estimate actual evapotranspiration through hydrological modeling. However, such a model needs to be validated before actual ET assessments for an area are obtained and used. However, the SWAT model can be used to simulate actual evapotranspiration on a continuous basis.

The SWAT model allows the use of a range of methods, including the Modified Penman-Monteith method, to calculate actual evapotranspiration, using daily weather data.

Detailed SWAT results have been presented in Final Report No. 4.2. Sample results for one of the sub-basins of Mahi basin are presented in Appendix 12 (Volume 2 of this report).

7.22 Summary of Agroclimatic Zone-wise Analysis of Weather Trends

7.22.1 Methodology

A trend analysis was performed by the Consultants using Mann Kendall statistics, which is a non-parametric trend statistic. Kendall's Tau was calculated for monotonic trends, which makes no assumptions about the distribution of the data or the linearity of any trends (Hollander and Wolfe, 1973 6). This statistic is also robust in the face of outliers. The Mann Kendall test has two parameters of importance for trend detection. These are the significance level, which indicates the test strength (p), and the value of Tau, which indicates the direction as well as the strength of the trend. Kendall's Tau is a measure of correlation; it measures the strength of association between the two variables. Kendall's Tau takes values between +1 and -1. A positive correlation indicates that ranks of both the variables increase together while a negative correlation indicates that as the rank of one variable increases while that of the other one decreases.

In hypothesis testing, the significance level is the criterion used for rejecting the null hypothesis. The significance level is used in hypothesis testing as follows:

- first, the difference between the results of the experiment and the null hypothesis is determined;
- then, assuming the null hypothesis is true, the probability of a difference being large or larger is computed;
- finally, this probability is compared to the significance level; if the probability is less than or equal to the significance level, then the null hypothesis is rejected and the outcome is said to be statistically significant.

The significance level is presented here as a confidence level, which is computed by:

confidence level = (1-significance level) × 100.

If the probability of occurring of an event is greater than or equal to the confidence level the outcome is said to be statistically significant. In this study trend is said to be significant only if confidence level is greater than 90%.

7.22.2 Results

ACZ Ia

Results of the temporal trend analysis of various weather parameters of ACZ Ia, Arid Western Zone, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	No significant trend	
Rainfall in July*	No significant trend	
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	No significant trend	
Relative Humidity	Significant trend	Decreasing
Sunshine Hours	No significant trend	
Mean Maximum Temperature	No significant trend	
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	Significant trend	Decreasing
Lowest minimum Temperature	No significant trend	
Wind Speed	Significant trend	Decreasing

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ Ib

Results of the temporal trend analysis of various weather parameters of ACZ Ib, Irrigated Northwestern Plain within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	Significant trend	Increasing
Rainfall in July*	No significant trend	
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	Significant trend	Decreasing
Relative Humidity	No Significant trend	
Sunshine Hours	Significant trend	Decreasing
Mean Maximum Temperature	No significant trend	
Mean Minimum Temperature	Significant trend	Increasing
Highest Maximum Temperature	No significant trend	
Lowest minimum Temperature	No significant trend	
Wind Speed	Significant trend	Decreasing

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ Ic

Results of the temporal trend analysis of various weather parameters of ACZ Ic, Hyper Arid Irrigated Western Plain (Partially), within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	Significant trend	Increasing
Rainfall in July*	No significant trend	
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	No significant trend	
Relative Humidity	No significant trend	
Sunshine Hours	Significant trend	Decreasing
Mean Maximum Temperature	No significant trend	
Mean Minimum Temperature	Significant trend	Increasing
Highest Maximum Temperature	Significant trend	Decreasing
Lowest minimum Temperature	Significant trend	Increasing
Wind Speed	No significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IIa

Results of the temporal trend analysis of various weather parameters of ACZ IIa, Transitional Plain of Inland Drainage, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	Significant trend	Increasing
Rainfall in July*	No significant trend	
Rainfall in Aug*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	Significant trend	Decreasing
Relative Humidity	No significant trend	
Sunshine Hours	Data not available	
Mean Maximum Temperature	Significant trend	Increasing
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	No significant trend	
Lowest minimum Temperature	No significant trend	
Wind Speed	No significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IIb

Results of the temporal trend analysis of various weather parameters of ACZ IIb, Transitional Plain of Luni Basin, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	No significant trend	
Rainfall in July*	No significant trend	
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	No significant trend	
Relative Humidity	Significant trend	Decreasing
Sunshine Hours	Data not available	
Mean Maximum Temperature	Significant trend	Increasing
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	No significant trend	
Lowest minimum Temperature	Significant trend	Increasing
Wind Speed	No significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IIIa

Results of the temporal trend analysis of various weather parameters of ACZ IIIa, Semi Arid Eastern Plain, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	No significant trend	
Rainfall in July*	No significant trend	
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	No significant trend	
Relative Humidity	No significant trend	
Sunshine Hours	No significant trend	
Mean Maximum Temperature	Significant trend	Increasing
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	No significant trend	
Lowest minimum Temperature	No significant trend	
Wind Speed	No Significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IIIb

Results of the temporal trend analysis of various weather parameters of ACZ IIIb, Flood Prone Eastern Plain, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	Significant trend	Increasing
Rainfall in July*	No significant trend	
Rainfall in August*	Significant trend	Decreasing
Rainfall in September*	No significant trend	
Evaporation	Data not available	
Relative Humidity	Significant trend	Increasing
Sunshine Hours	Data not available	
Mean Maximum Temperature	Significant trend	Decreasing
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	Significant trend	Decreasing
Lowest minimum Temperature	No significant trend	
Wind Speed	Data not available	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IVa

Results of the temporal trend analysis of various weather parameters of ACZ IVa, Sub-Humid Southern Plain, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	No significant trend	
Rainfall in July*	Significant trend	Increasing
Rainfall in August*	No significant trend	
Rainfall in September*	No significant trend	
Evaporation	No Significant trend	
Relative Humidity	No significant trend	
Sunshine Hours	Data not available	
Mean Maximum Temperature	Significant trend	Increasing
Mean Minimum Temperature	Significant trend	Increasing
Highest Maximum Temperature	No significant trend	
Lowest minimum Temperature	Significant trend	Increasing
Wind Speed	No significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ IVb

Results of the temporal trend analysis of various weather parameters of ACZ IVb, Humid Southern Plain, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June	No significant trend	
Rainfall in July	Significant trend	Increasing
Rainfall in August	No significant trend	
Rainfall in September	No significant trend	
Evaporation	No significant trend	
Relative Humidity	No significant trend	
Sunshine Hours	Data not available	
Mean Maximum Temperature	No significant trend	
Mean Minimum Temperature	No significant trend	
Highest Maximum Temperature	Significant trend	Decreasing
Lowest minimum Temperature	No significant trend	
Wind Speed	Data not available	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

ACZ V

Results of the temporal trend analysis of various weather parameters of ACZ V, Humid Southeastern Plain, within the study period of 20 years (1990-2009) are summarized in the following table.

Weather Parameter	Trend	Remarks
Number of rainy days*	No significant trend	
Rainfall in June*	No significant trend	
Rainfall in July*	No significant trend	
Rainfall in August*	Significant trend	Decreasing
Rainfall in September*	No significant trend	
Evaporation	No significant trend	
Relative Humidity	No significant trend	
Sunshine Hours	Data not available	
Mean Maximum Temperature	No significant trend	
Mean Minimum Temperature	Significant trend	Increasing
Highest Maximum Temperature	Significant trend	Decreasing
Lowest minimum Temperature	Significant trend	Increasing
Wind Speed	No Significant trend	

* Number of rainy days and Monsoon Rainfall trends were performed with rainfall data of 54 years (1957-2010)

8. Stream Discharge Analysis

Stream discharge analysis was performed for selected sites within various basins as per data availability and their location in the basin. The stream gauge data validation is still under process and after refinement and validation it will be used as an input for hydrological modelling.

Stream gauge discharge data for selected sites were analysed and Discharge-Time curves were plotted along with Flow duration curves.

Frequency analysis takes a different approach in characterising baseflow by deriving the relationship between the magnitude and frequency of streamflow discharges from the hydrographic record. In its most common application, a flow duration curve (FDC) is generated. Instead of plotting as a time series, a flow duration curve shows the percentage of time that a given flow rate is equalled or exceeded (probability of occurrence). The FDC is constructed from flow data of fixed time period (e.g. daily, monthly, annually) by:

1. sorting the flow data in order of decreasing flow;
2. assigning a unique ranking number m to each flow, starting with 1 for the maximum flow to n for the minimum flow, where n is the number of flow measurements.
3. the probability p that a given flow will be equalled or exceeded is defined by: $p = 100 \times m/(n+1)$
4. the flow-probability relationship is typically presented as a log-normal plot (fetter, 1994).

The FDC provides information on the baseflow component of stream flow. The median flow (Q50) is the discharge which is equalled or exceeded 50% of the time. The part of the curve with flows below the median flow represents low-flow conditions. Baseflow is interpreted to be significant if this part of the curve has a low slope, as this reflects continuous discharge to the stream. A steep slope for these low-flows suggests relatively small contributions from natural storages like groundwater. These streams may cease to flow for relatively long periods. In this way, the shape of the FDC can indicate the hydrogeological characteristics of a catchment (Smakhtin, 2001).

Flow duration curves for selected sites in various agroclimatic zones are presented in Appendix 13 (Volume 2 of this report).

9. Agro-Economic Zones of Rajasthan

9.1 Introduction

Since socio-economic factors directly influence agricultural production, the Planning Commission in its Report of the Committee on 25 Years Perspective Plan for the Development of Rain-fed Areas (1997) divided the country into four agro-economic zones on the basis of certain agro-economic characteristics like level of land productivity, incidence of rural poverty etc. These agro-economic zones have the following features:

- Zone I: areas with relatively high productivity, with either high levels of irrigation or high assured rainfall and low incidence of poverty
- Zone II: areas with relatively low productivity, high rainfall, low level of irrigation and high incidence of poverty
- Zone III: areas with low productivity, low rainfall and high incidence of poverty.
- Zone IV: ecologically fragile areas, including the desert areas of Rajasthan and Gujarat; this zone has lot of intra-zonal variations in the levels of productivity, poverty, irrigation, etc.

9.2 Potential of the Agro-Economic Zones

9.2.1 Zone I

This is an area with relatively high productivity, either high level of irrigation or high assured rainfall and low incidence of poverty. The annual rainfall of Ganganagar and Hanumangarh Districts are 226.4 mm and 273.5 mm, respectively. Ganganagar and Hanumangarh Districts, falling in agroclimatic zone IB, have relatively high productivity due to high level of irrigation facilities and low incidence of poverty. The Irrigation Department has provided increased water allowance for orchard crops, due to which a large number of orchards, particularly of citrus, have been established. Ancillary units for the production of citrus-based processed products have also been developed. Major Kharif crops grown are cotton, groundnut, sugarcane and guar, and wheat, gram, mustard, sugar beet and barley are grown in the Rabi season. In order to protect the orchard crops from climatic extremities, including frost, planting of tall trees all around the orchards has been resorted to. Under a newly introduced scheme of the Horticulture Department, farmers are provided subsidy and encouraged to construct reservoirs in their farms. Water stored in these reservoirs is utilised not only to irrigate crops during canal closures but also to raise certain cash crops like vegetables etc., which give higher net returns.

9.2.2 Zone II

In Chittorgarh, the rocky strata make the installation of tube wells for irrigation difficult. Therefore, tank and dug-well irrigation have to be resorted to, although even these are often inadequate. In Jhalawar, irrigation and rainwater management are crucial for crop production.

The region has good potential for horticulture development but adoption of drip irrigation and development of proper marketing and transportation facilities for horticultural products are important for the development of this zone. Promotion of drip irrigation is part of the horticulture development programme and is becoming popular. The need for subsidies could be obviated by lifting all levies on raw materials required for manufacturing these items and this would bring down their market prices. Cultivation of durum (hard wheat), which has a good market both within India and abroad, needs to be extended in this zone with appropriate varieties and extension efforts. The agricultural research system should develop high yielding and low input varieties of durum which are more remunerative than the *aestivum* wheat. Efforts should be made for durum farming on a contract basis with a buy-back guarantee. Indigenous varieties like *kharchiya, malvi* and *ikdania* must be protected and improved.

9.2.3 Zone III

The irrigated belt comprising Sri Ganganagar (including Hanumangarh) and the north-western part of Bikaner, face problems of soil salinity and alkalinity to a varying extent. The State Government should make concerted efforts on the lines of Uttar Pradesh’s Sodic Land Development project funded by the World Bank. The technology for addressing the problem has been developed by the Central Soil Salinity Research Institute at Karnal. Sand dunes of varying height need stabilisation, for which Central Arid Zone Research Institute (CAZRI) has developed appropriate technologies for adoption.

In Ajmer, Jaipur and Tonk districts and certain other western parts of the State, high-velocity summer winds cause soil erosion. Appropriate windbreaks could save cultivated fields to a considerable degree. Mechanical measures and biological methods have been developed for sand dune fixation. Hedge or micro-wind-break has been found to be an effective mechanical method. A number of grasses, shrubs and tree species have been identified for the biological method of fixation. Suitable species have also been suggested for the Indira Gandhi Nahar Project (IGNP) areas. Technologies for seeding, planting techniques, agro-forestry, cost-effective forestation and people’s participation as a complete package have been emphasised. In the Pushkar area of Ajmer District, there is tremendous potential for the development of floriculture. Windbreaks of suitable species with varying heights are recommended for planting to combat wind erosion.

In parts of Udaipur, Bhilwara, Chittorgarh and Sirohi Districts, barren cultivable wastelands constitute over 30 per cent of the total area, which needs to be reclaimed particularly for permanent pastures and grazing land to support livestock rearing.

Rose cultivation has good potential in Udaipur, Pushkar and Haldighati (Rajsamand District) areas. Breeding of high-yielding and fragrancive varieties with proper processing, packing, marketing and transportation is necessary. The State Horticulture Department must undertake a study to work out research and other requirements for distillation and redistillation processes. The field distillation process developed by the National Botanical Research Institute, Lucknow, could be tried and growers provided technologies for packaging. Marketing arrangements like processing, grading, etc., may be developed to ensure good returns to the producers

9.2.4 Zone IV

In the desert areas of Barmer, Bikaner, Churu, Sikar, Jaisalmer, Jalore, Jodhpur, Nagaur and Jhunjhunu, shifting sand dunes and inadequate water availability are major constraints to development, especially in agro-forestry and animal husbandry which have good potential. CAZRI has developed technologies for arid horticulture, especially of ber, pomegranate and khejri. This region lacks infrastructure like roads, markets, power, cold storage, banks, etc., which impede development.

Ultimately, farm productivity can be raised only by developing water resources. Further, the State Agriculture and Forest Departments must prepare district-specific crop and tree species under a master plan for sustainable natural resource exploitation.

10. Agronomic Status of Rajasthan

10.1 Background

Rajasthan is the largest state in the country, covering an area of 34.3 million ha, which is more than 10% of the total geographical area of the country. About 5% of the total population of the country resides in the State and it has more than 15.7 million ha of land suitable for agriculture. Rajasthan is one of the driest states of the country and the total surface water resources in the state are only about 1% of the total surface water resources of the country. The rivers of the State depend on rain and that too for short spans.

Rajasthan is divided into fifteen river basins. The surface water resources in the state are mainly confined to its south and south-eastern parts. A vast area in the western part of the State does not have any defined drainage basin. Thus the water resources in the state are not only scarce but have highly uneven distribution both in time and space.

Groundwater plays an important role, especially in agriculture and drinking water supply. The situation of groundwater exploitation is also unsatisfactory. Whereas in areas where surface irrigation is practised there is a tendency of not using groundwater for agriculture, in large areas of the State, groundwater is over-exploited and the water table is in general declining. Substantial measures to recharge groundwater are in general not being adopted.

Agriculture and animal husbandry are the main occupations of the majority of people in Rajasthan. The western region depends mainly on animal husbandry and is widely known for local animal breeds, both for milk and draught power.

Agriculture in Rajasthan is mostly dependent on the Monsoon, which is not only erratic and uncertain but also has a short time-span. In terms of agro-climatic characteristics, the State ranges from arid to semi-arid. Rivers in Rajasthan are non-perennial except for Chambal and Mahi. For development studies, the state has been categorised into ten agro-climatic zones.

The main Kharif crops of the State are bajra, jowar, maize, Kharif pulses, guar, cotton and soyabean, and the main Rabi crops are wheat, gram, rape-seed and mustard.

Rajasthan has made substantial improvement in crop production, especially after the Green Revolution. The area and production of crops like wheat, rapeseed and mustard, Rabi pulses, and cotton have increased. There has been negative growth in coarse cereals and Kharif pulses, whereas Rabi crops like wheat, rapeseed and mustard have recorded positive growth. Although the total quantity of seeds distributed has increased, crop-wise figures of seeds distributed show some distortions. The consumption of fertilisers is nearly half of the national average. The indiscriminate use of fertilisers and that too in wrong proportions, is a cause for concern. The use of organic manure is very low.

Horticultural development and agro-processing in the State are very weak and need improvement. On-farm water management is an area of great concern in irrigated areas and needs to be given attention to improve water use efficiency.

Nearly 70 per cent of the cultivated area in Rajasthan is rain-fed. As the rainfall is meagre and erratic, agriculture is full of risks and uncertainties. The subsistence type of agriculture prevalent in the State puts extra burden on natural resources like land, water and vegetation. It has been observed that since 1974-75, 2.2 million hectares (ha) have been treated under the watershed development programs of Drought-Prone Area Program (DPAP), Desert Development Program (DDP), National Watershed Development Program for Rain-fed Agriculture (NWDPRA), externally aided watershed projects, etc. However, the sustainability of work done is an issue. Agricultural mechanisation, which can benefit both rain-fed and irrigated areas, is also a neglected area.

Groundwater is mainly used for irrigation purposes and this result in over-exploitation of the resource, the regeneration of which is dependent on rains. There are large areas in the State where water resources have been seriously over-exploited and groundwater is fast depleting. Artificial recharge can mitigate the negative impacts of aquifer overdraft.

Rajasthan is animal-wealthy and has the distinction of having the largest population of cattle, sheep and camels. The state produces 10% of the country’s milk, and 30% meat, and has the highest share of wool production.

A significant portion of the economy of Rajasthan is agrarian; the agricultural sector of the state contributes 22.5% to the State GDP.

The total cultivated area of the State encompasses about 20 million hectares, out of which only 30% is irrigated. Groundwater level depth varies at present between one and 120 m. Rajasthan farmers have different sources of irrigation by groundwater, including tube wells, dug wells and tanks.

The Punjab Rivers in the north, the Narmada River in the south and the Agra Canals from Haryana and Uttar Pradesh provide water to the dry lands of Rajasthan. North-western Rajasthan is irrigated by the Indira Gandhi Canal, Gang Canal and Bhakra Canal and Sidhmukh and Nohar projects.

Irrigation intensity in Rajasthan during the year 2009-10 was 125%, and the cropping intensity – 128%.

The climatic conditions of the region affect the choice of cropping patterns in different areas, thus producing different crops. Rainfall, temperature, humidity, wind velocity and duration of sunshine, significantly affect the choice of crop and adoption of cropping patterns. Rainfall and its distribution over the year, and the regimes of diurnal and annual temperatures are, by far, the prominent factors affecting agriculture and the life style of people.

The State's mean annual rainfall is 495.6 mm (see Table 7.8 above), and the average number of rainy days per year is 27.

The surface water resources in the State are mainly confined to the southern and south-eastern parts. A vast area in the western part of the State does not have a defined drainage basin.

Thus the water resources in the state are not only scarce but have highly uneven distribution both in time and space.

10.2 Cropping Patterns

Table 10.1 below shows the cropping patterns prevailing in the different districts, based upon district-wise areas of the main crops.

The district-wise sown areas of major crops during Kharif and Rabi season 2009-10 clearly indicate that water availability, cost of input and market prices have a major role in the selection of crops.

Table 10.2 shows the changes in cropping patterns over the Five-Year Plans.

Table 10.1 Cropping Patterns by ACZ

ACZ	District	Cropping Pattern	
		Kharif	Rabi
Ia	Part of Barmer (Barmer, Balotra, Baytoo, Chohtan, Dhorimanna, Sindhari, Sheo) and Jodhpur (Balesar, Bap, Part Of Bhopalgarh, Luni, Mandore, Osian, Phalodi, Shergarh)	Bajra, Bajra	Isabgol, Mustard
Ib	Ganganagar and Hanumangarh	Jowar, Guar	Mustard, Wheat
Ic	Bikaner, Jaisalmer and Part of Churu (Ratangarh, Sardarshahar, Sujangarh)	Guar, Bajra	Gram, Gram
IIa	Nagaur, Sikar, Jhunjhunu And Part of Churu (Churu, Rajgarh, Taranagar)	Bajra, Bajra	Wheat, Gram
IIb	Jalore, Jodhpur (Bilara, Part of Bhopalgarh) Part of Sirohi (Reodhar, Sheoganj, Sirohi), Barmer (Siwana) and Pali	Bajra, Maize, Sesamum	Mustard, Wheat, Wheat
IIIa	Ajmer, Tonk, Jaipur, and Part of Dausa (Bandikui, Dausa, Lalsot, Sikrai)	Jowar, Bajra	Wheat, Wheat

ACZ	District	Cropping Pattern	
		Kharif	Rabi
IIIb	Alwar,		
	Bharatpur,		
	Dhaulpur,	Bajra,	Mustard,
	Karauli,		
	Sawai Madhopur (Bamanwas, Bonli, Gangapur)		
	and		
	Part of Dausa (Mahuwa)	Bajra	Wheat
IVa	Bhilwara,		
	Chittaurgarh,		
	Rajsamand,		
	Part of Sirohi (Abu Road, Pindwara),		
	Udaipur (Bargain, Bhinder, Girwa, Gogunda, Kherwara, Kotra,	Maize,	Wheat,
	Jhadol, Mavli, Sarada)		
	and		
	Pratapgarh (Choti Sadri, Pratapgarh)	Soyabean	Wheat
IVb	Dungarpur,	Maize,	Wheat,
	Banswara,		
	Part of Udaipur (Salumber)		
	and		
	Pratapgarh (Dhariyawad, Peepalkhunt, Arnod)	Soyabean	Wheat
V	Baran,	Soyabean,	Mustard,
	Bundi,	Soyabean,	Wheat,
	Kota		
	Jhalawar,	Soyabean,	Coriander,
	and		
	Part of Sawai Madhopur (Khandar, Sawai Madhopur)	Bajra	Mustard

Based upon Rajasthan Agriculture Statistics at a Glance 2009-10

Major crops grown in Rajasthan during Kharif are bajra, jowar, maize, moth, pulses, guar, groundnuts, cotton, soyabean, and rice. During Rabi - wheat, gram and mustard. The cropping pattern has changed over the last five decades as a result of development of irrigation, adoption of appropriate production technologies, better market prices, enhanced industrial demand, etc.

Table 10.2 Plan-wise Cropping Patterns, Percent

Crops	Plan I	Plan II	Plan III	Plan IV	Plan V	Plan VI	Plan VII	Plan VIII	Plan IX	Plan X
Bajra	28.2	29.3	30.1	31.2	23.9	26.7	28.3	23.3	21.9	25.2
Guar	0.0	0.0	0.0	6.4	11.5	10.9	10.0	9.3	9.4	7.5
Maize	4.4	4.3	4.7	4.8	4.5	5.0	5.3	4.6	4.4	7.5
Jowar	9.5	7.8	7.7	6.5	4.7	5.2	5.6	3.3	3.5	3.9
Soyabean	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.2	1.8
Sesamum	3.7	3.5	3.8	3.0	2.3	2.3	2.1	2.1	2.0	1.8
Groundnuts	0.3	0.6	1.2	1.4	1.7	1.1	1.3	1.2	1.2	1.6
Wheat	7.9	8.6	7.8	8.9	10.6	10.3	10.0	11.2	12.1	18.0
Mustard	1.4	1.8	1.8	1.8	1.9	3.9	6.4	12.0	11.6	16.0
Gram	8.6	10.3	9.6	8.7	10.4	9.1	7.5	7.0	7.4	6.5
Barley	4.6	3.9	3.1	3.0	3.4	2.0	1.5	1.0	1.0	1.6

Source: Rajasthan State Department of Agriculture, Jaipur

There was a negative growth rate in the area under coarse cereals and Kharif pulses, whereas there was a moderate growth in area under groundnuts. However, there was an increase in growth rate in area under cotton and a very high growth rate in soyabean among the Kharif crops. For *Rabi* crops, the compound growth rate was positive for all crops except barley. Mustard areas have greatly increased due to higher economic returns.

10.3 Cropping Intensity

The district-wise and agroclimatic zone-wise cropping intensity status in Rajasthan in the years 2009-2010 is shown in Table 10.3 and 10.4, respectively.

Table 10.3 District-wise Cropping Intensity in 2009-2010

District	Net Sown Area, 10^3 ha	Gross Sown Area, 10^3 ha	Cropping Intensity, %
Ajmer	417.1	436.0	105
Alwar	504.7	864.5	171
Banswara	224.3	324.6	145
Baran	338.9	546.9	161
Barmer	1,701.8	1,820.0	107
Bharatpur	396.0	603.1	152
Bhilwara	391.2	455.9	117
Bikaner	1,356.0	1,501.8	111
Bundi	251.1	383.8	153
Chittorgarh	297.7	422.5	142
Churu	1,128.3	1,283.2	114
Dausa	226.7	381.6	168
Dholpur	153.5	229.3	149
Dungarpur	133.3	186.4	140
Ganganagar	675.2	946.6	140
Hanumangarh	733.7	1,013.6	138
Jaipur	653.2	934.2	143
Jaisalmer	546.7	626.2	115
Jalore	651.6	824.5	127
Jhalawar	328.6	579.0	176
Jhunjhunu	404.2	613.8	152
Jodhpur	1,256.5	1,401.9	112
Karauli	201.8	348.5	173
Kota	271.3	438.9	162
Nagaur	1,235.4	1,411.0	114
Pali	600.7	629.9	105
Pratapgarh	172.6	267.9	155
Rajsamand	89.1	99.2	111
S.Madhopur	287.0	425.4	148
Sikar	511.5	715.0	140
Sirohi	137.8	171.2	124
Tonk	460.9	571.8	124
Udaipur	236.1	286.8	121
Rajasthan State	16,974.5	21,744.9	128

Source: Agricultural Statistics of Rajasthan, 2009-10

Table 10.4 Agroclimatic zone-wise Cropping Intensity in 2009-2010

Agroclimatic Zones	Net Sown Area, 10^3 ha	Gross Sown Area, 10^3 ha	Cropping Intensity, %
Ia	2,642.3	2,875.1	109
Ib	1,408.9	1,960.2	139
Ic	2,573.2	2,890.6	112
IIa	2,603.4	3,252.1	125
IIb	1,652.3	1,905.6	115
IIIa	1,713.6	2,256.3	132
IIIb	1,426.7	2,305.0	162
IVa	1,135.7	1,441.4	127
IVb	473.4	680.2	144
V	1,345.0	2,178.5	162
Rajasthan State	16,974.5	21,744.9	128

10.4 Irrigation

Irrigation is the most important input for achieving increased and sustainable agricultural production. Being an arid to semi-arid state, development of water resources for irrigation has the highest priority in Rajasthan. Over the past two decades, irrigation has been supported under various schemes such as the National Watershed Development Programme (NWDP), Drought Prone Area Programme (DPAP), Desert Development Programme (DDP), etc. The ratio of irrigated area to net sown area was only 13.4% in 1960-61, which increased to 28.1% in 2009-10 (Table 10.5). Table 10.6 show irrigation efficiency values per district, while Table 10.7 show irrigation efficiency values per agroclimatic zone for the year 2009-2010.

Although the State has made good progress on the irrigation front, more planned and sustained efforts are required to ensure optimum use of the scarce water resources.

Table 10.5 Irrigated Areas and Irrigation Intensity

Year	Irrigated area to net sown area, %	Irrigation intensity, %
1960-61	13.4	119.0
1970-71	14.1	114.8
1980-81	19.5	125.7
1990-91	28.0	121.2
2000-01	31.0	109.3
2009-10	28.1	124.9

Source: Statistical Cell, Directorate of Agriculture, Rajasthan, Jaipur and official websites of Govt. of Rajasthan and Govt. of India

Table 10.6 District-wise Irrigation Intensity (2009-2010)

Districts	Net Irrigated Area, ha	Gross Irrigated Area, ha	Irrigation Intensity, %
Ajmer	26,367	33,752	128
Alwar	455,957	489,284	107
Banswara	90,526	92,794	103
Baran	299,185	311,976	104
Barmer	147,383	223,991	152
Bharatpur	324,934	329,359	101
Bhilwara	69,902	78,576	112
Bikaner	217,689	343,156	158
Bundi	169,746	213,837	126
Chittorgarh	130,780	138,657	106
Churu	72,778	101,405	139
Dausa	160,093	168,600	105
Dholpur	113,814	115,169	101
Dungarpur	35,850	37,693	105
Ganganagar	527,404	788,016	149
Hanumangarh	370,846	636,384	172
Jaipur	289,407	375,199	130
Jaisalmer	80,020	157,235	196
Jalore	233,615	276,656	118
Jhalawar	230,159	241,601	105
Jhunjhunu	223,931	252,158	113
Jodhpur	225,687	351,576	156
Karauli	121,326	122,719	101
Kota	230,204	251,041	109
Nagaur	240,010	319,318	133
Pali	47,193	52,795	112
Pratapgarh	81,860	83,215	102
Rajsamand	12,916	15,775	122
S.Madhopur	177,530	180,601	102
Sikar	231,718	297,683	128
Sirohi	39,597	50,256	127
Tonk	125,743	130,484	104
Udaipur	45,744	47,812	105
Rajasthan State	5,849,914	7,308,773	125

Source: Rajasthan Agricultural Statistics at a glance 2009-10

Table 10.7 Agroclimatic Zone-wise Irrigation Intensity (2009-2010)

Agroclimatic Zones	Net Irrigated Area, ha	Gross Irrigated Area, ha	Irrigation Intensity, %
Ia	327,871	505,565	154
Ib	898,250	1,424,400	159
Ic	340,961	560,656	164
IIa	725,185	910,299	126
IIb	350,187	430,129	123
IIIa	577,589	682,576	118
IIIb	1,120,978	1,164,154	104

Agroclimatic Zones	Net Irrigated Area, ha	Gross Irrigated Area, ha	Irrigation Intensity, %
IVa	311,128	337,361	108
IVb	172,534	177,582	103
V	1,025,231	1,116,052	109
Rajasthan State	5,849,914	7,308,773	125

Crop yields attained in irrigated areas in Rajasthan are shown in Table 10.8 below.

Table 10.8 Plan-Wise Gross Irrigated Area and Food Grain Production

Plan	Gross Irrigated Area, ×100,000 ha	Food Grains Production, ×100,000 tons
I	14.39	39.98
II	18.29	46.40
III	19.39	47.57
IV	25.35	63.49
V	31.34	70.36
VI	38.80	79.93
VII	42.07	77.77
VIII	58.14	105.65
IX	-	121.94

Source: Statistical Cell, Directorate of Agriculture, Rajasthan, Jaipur and official websites of Govt. of Rajasthan and Govt. of India.

Canals are the main source of irrigation in the North Western Plain Zone and provide more-or-less assured irrigation, while the maximum irrigated area in other zones is under dug-wells, canals and tubewells. These areas account for 99% of total tanks in the State. An important source of irrigation water in the western dry region is dug wells and tube-wells. In addition, a considerable part of Western Rajasthan is irrigated by Narmada, Gang, Bhakra and Indira Gandhi canals.

As of 1997-98, wells provided irrigation in 29.54 million ha, or 55% of the State's total irrigated area. Canals supply irrigation water to 28.1% of the total net irrigated area. Tanks and other minor sources are important locally. Barring canals, all other sources of irrigation depend on rains for their recharge.

10.5 Area and Production of Principal Crops

The status of principal crops in Rajasthan is summarised in Table 10.9, giving details of area (ha) and yield (kg/ha) for the year 2009-10. Crops having large area under cultivation are wheat, mustard, guar, bajra, moth and maize. Crops which have comparatively low productivity level are moth, cowpea and guar. This is because of the fact that these are mostly cultivated in arid regions of western Rajasthan having low and erratic rainfall. Table 10.10 shows area and yield of principal crops per agroclimatic zone for the year 2009-2010.

Table 10.9 Status of Principal Crops in Rajasthan (2009-2010)

Crops	Area, ha	Yield, kg/ha
Kharif		
Rice	150,691	1,515
Jowar	718,457	145
Bajra	5,168,502	394
Maize	1,096,231	1,044
Moong	922,885	47
Urad	116,377	264
Moth	1,272,785	31
Cowpea	124,407	93
Arhar	18,346	380
Sesamum	598,306	163
Groundnut	326,032	1,071
Soyabean	778,382	1,174
Castor Seed	117,211	735
Cotton	444,431	345
Guar	258,1273	78
Rabi		
Wheat	2,394,215	3,133
Barley	223,406	2,812
Gram	884,358	605
Peas	2,761	1,760
Lentil	27,047	895
Mustard	2,212,339	1,316
Taramira	97,542	368
Linseed	3,260	2,006
Isabgol	227,705	615

Source: Rajasthan Agricultural Statistics at a Glance 2009-10

Table 10.10 Agroclimatic Zone-wise Status of Principal Crops in Rajasthan (2009-2010)

Crops	ACZ Ia		ACZ Ib		ACZ Ic		ACZ IIa		ACZ IIb		ACZ IIIa		ACZ IIIb		ACZ IVa		ACZ IVb		ACZ V	
	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha	Area, ha	Yield, kg/ha
Kharif																				
Rice	-	-	33,375	3,229	63	1,508	-	-	-	-	14	1,571	3,875	1,507	5,711	930	43,411	414	64,242	1,421
Jowar	54,021	6	527	146	1,110	81	53,816	73	148,786	11	268,892	40	107,008	480	67,455	253	2,197	404	14,645	1,227
Bajra	1,374,120	25	57,698	494	650,995	38	1,202,999	350	574,584	41	565,527	778	679,067	1,471	12,131	184	390	394	50,990	1,194
Maize	15	1,055	3	1,000	7	1,000	76	737	37,553	369	52,902	158	8,548	894	618,287	1,123	279,587	934	99,251	1,603
Moong	127,741	11	32,985	336	22,891	24	313,832	63	218,704	11	184,009	38	254	44	21,786	76	117	44	567	48
Urad	-	-	607	253	-	-	-	-	816	120	14,574	51	1,203	275	53,326	170	25,967	445	19,885	440
Moth	359,575	13	42,410	150	454,718	32	334,933	37	78,010	21	2,814	9	204	29	72	N.A.	-	-	49	32
Cowpea	23	111	9	111	321	51	108,069	86	1,721	40	13,233	165	41	99	811	56	114	91	65	77
Arhar	-	-	106	85	15	267	209	63	283	N.A.	318	165	3,971	547	4,009	453	8,860	269	575	927
Sesamum	34,571	10	9,730	464	5,707	39	19,967	22	187,548	14	138,590	123	70,386	452	46,831	123	2,667	204	82,309	413
Groundnut	37,838	1,219	9,475	955	101,258	905	47,064	1,333	13,341	1,104	68,465	1,231	7,690	1,219	33,936	720	1,043	1,027	5,922	940
Soyabean	-	-	-	-	-	-	1	1,000	-	-	117	1,178	356	1,097	92,901	1,280	68,786	1,348	616,221	1,139
Castor Seed	33,008	412	2,199	1,144	1,236	222	169	456	69,002	967	173	84	6	837	11,332	256	82	51	4	2,250
Cotton	9,352	415	338,553	363	5,241	67	18,287	477	7,704	309	6,803	136	4,645	387	41,132	209	12,651	298	63	342
Guar	453,092	1	348,175	240	1,139,107	44	332,292	64	157,644	29	68,951	270	38,069	360	38,248	186	4,981	228	713	303
Rabi																				
Wheat	59,135	2,266	419,607	2,938	80,191	1,705	256,507	3,004	75,549	2,101	259,410	3,179	525,066	3,820	169,421	2,941	144,103	2,174	405,226	3,519
Barley	438	2,774	48,487	2,902	7,116	1,722	54,673	2,834	2,638	2,390	64,668	2,861	21,516	3,434	17,822	2,265	3,580	2,041	2,469	2,528
Gram	139	610	230,309	496	267,896	360	167,863	665	275	819	22,232	678	55,189	1,058	23,704	969	38,808	1,099	77,942	937
Peas	-	-	78	1,974	25	560	1,569	1,866	-	-	80	1,266	368	1,621	151	1,041	15	1,385	475	1,868
Lentil	-	-	12	917	1	1,000	-	-	2	1,000	709	894	2,188	864	6,347	678	1,571	852	16,217	988
Mustard	78,515	1,195	302,524	1,544	73,604	725	190,559	1,269	90,359	1,222	342,949	950	680,174	1,527	63,361	1,093	4,485	1,152	385,809	1,315
Taramira	695	350	12,721	256	2,585	327	1,081	660	1,160	942	51,481	379	12,898	368	2,263	372	245	368	12,413	368
Linseed	-	-	135	1,311	2	1,000	1,936	1,935	1	1,000	4	496	2	1,000	136	532	38	516	1,006	2,501
Isabgol	93,881	553	1	1,000	26,877	347	51,582	885	52,130	597	24	600	-	-	2,380	615	644	615	187	615

N.A. - Not Available

Source: Rajasthan Agricultural Statistics at a Glance 2009-10

10.6 Land Use Patterns

Table 10.11 and Figure 10.1 below show the decadal changes in the land utilization pattern from 1960-61 to 2000-01. In 1960-61, 38.7% of the State's area was utilized for crop production. This increased to 46.3% in 2000-01. In 2009-10 it further increased to 49.5%. Thus, within four decades the net cropped area increased by 28.9%, whereas the gross cropped area showed an increase of 58.5%, largely due to increase in irrigated area. The cultivable wasteland decreased from 20.2% to 13.3% in the same period. This change has been more pronounced in the western dry region during the Seventh to Eighth Plan periods. Such decline in cultivable waste and fallow area has been reflected in an increase in the net sown area. The area under forests increased from 2.4% to 8% during the same period. However, these data do not provide a realistic picture of the forest cover in Rajasthan as only 11.2% of the forest area is dense, while 59% area is under scrubs. One disturbing feature is the significant increase in the area under non-agricultural use. Therefore, appropriate policies are needed to prevent fertile agriculture land being put to non-agricultural use and to properly utilize current fallow lands. An effective balance between agricultural development and urbanization needs to be maintained, which will also benefit the environment.

Figures 10.2 show land-use percentages of the State area.

Figure 10.1 Decadal Percentage Change in Land use

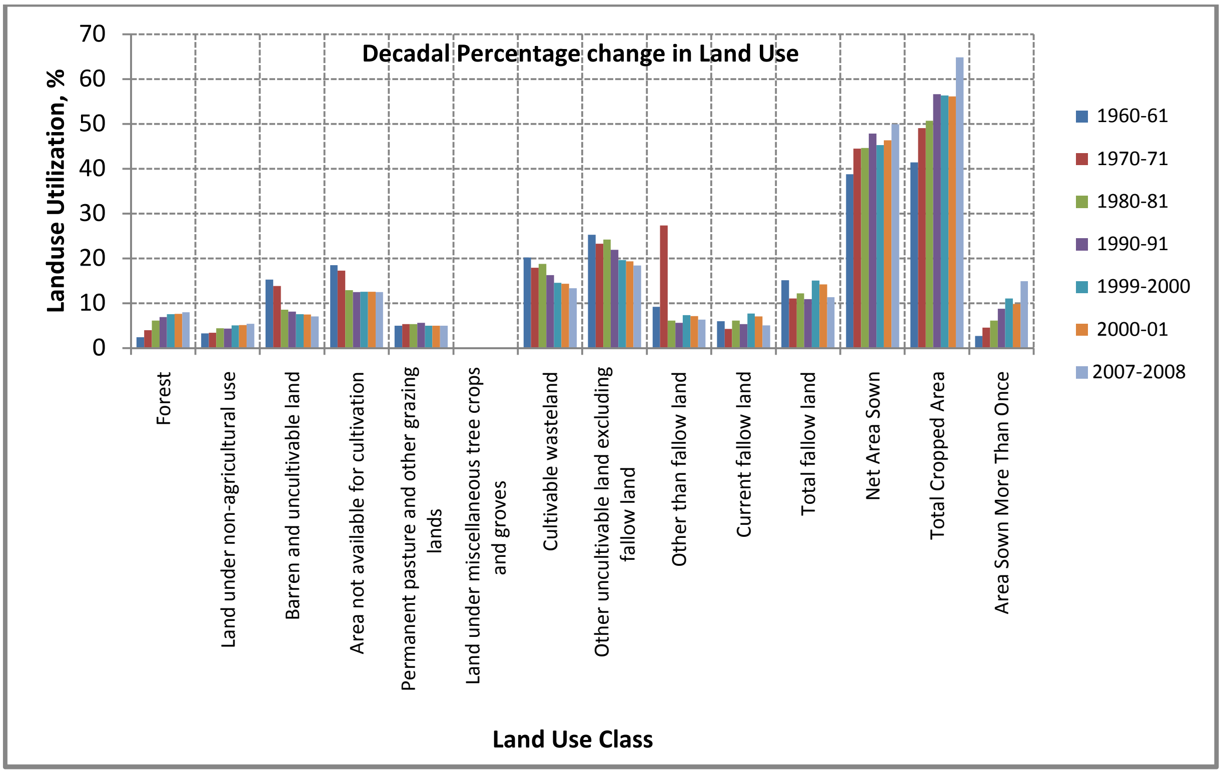


Table 10.11 Land Utilization Patterns

Areas in '000 ha

	1960-61		1970-71		1980-81		1990-91		1999-2000		2000-01		2007-2008	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Geographical Area	33,841	100.0	34,109	100.0	34,227	100.0	34,252	100.0	34,258	100.0	34,265	100.0	34,269	100.0
Forest	814	2.4	1,355	4.0	2,088	6.1	2,353	6.9	2,580	7.5	2,606	7.6	2,727	8.0
Land under non-agricultural use	1,095	3.2	1,162	3.4	1,507	4.4	1,490	4.4	1,725	5.0	1,740	5.1	1,844	5.4
Barren and uncultivable land	5,153	15.2	4,716	13.8	2,917	8.5	2,790	8.1	2,580	7.5	2,566	7.5	2,418	7.1
Area not available for cultivation	6,248	18.5	5,878	17.2	4,424	12.9	4,280	12.5	4,305	12.6	4,306	12.6	4,264	12.5
Permanent pasture and other grazing lands	1,684	5.0	1,807	5.3	1,834	5.4	1,912	5.6	1,714	5.0	1,707	5.0	1,702	5.0
Land under miscellaneous tree crops and groves	16	0.0	9	0.0	24	0.1	22	0.1	14	0.0	14	0.0	16	0.1
Cultivable wasteland	6,841	20.2	6,112	17.9	6,415	18.7	5,567	16.3	4,988	14.6	4,908	14.3	4,573	13.3
Other uncultivable land excluding fallow land	8,541	25.2	7,928	23.2	8,273	24.2	7,501	21.9	6,716	19.6	6,629	19.3	6,289	18.4
Other than fallow land	3,104	9.2	9,326	27.3	2,089	6.1	1,927	5.6	2,511	7.3	2,444	7.1	2,137	6.3
Current fallow land	2,022	6.0	1,443	4.2	2,085	6.1	1,814	5.3	2,637	7.7	2,415	7.1	1,664	5.0
Total fallow land	5,126	15.1	3,769	11.0	4,174	12.2	3,741	10.9	5,148	15.0	4,859	14.2	3,801	11.4
Net Area Sown	13,112	38.7	15,179	44.5	15,268	44.6	16,377	47.8	15,509	45.3	15,865	46.3	17,096	49.9
Total Cropped Area	14,013	41.4	16,720	49.0	17,350	50.7	19,380	56.6	19,286	56.3	19,230	56.1	22,208	64.8
Area Sown More Than Once	901	2.7 (6.5)	1,550	4.5 (9.3)	2,082	6.1 (12.0)	3,003	8.8 (15.5)	3,777	11.0 (19.6)	3,365	9.8 (17.5)	5,018	14.9 (22.6)

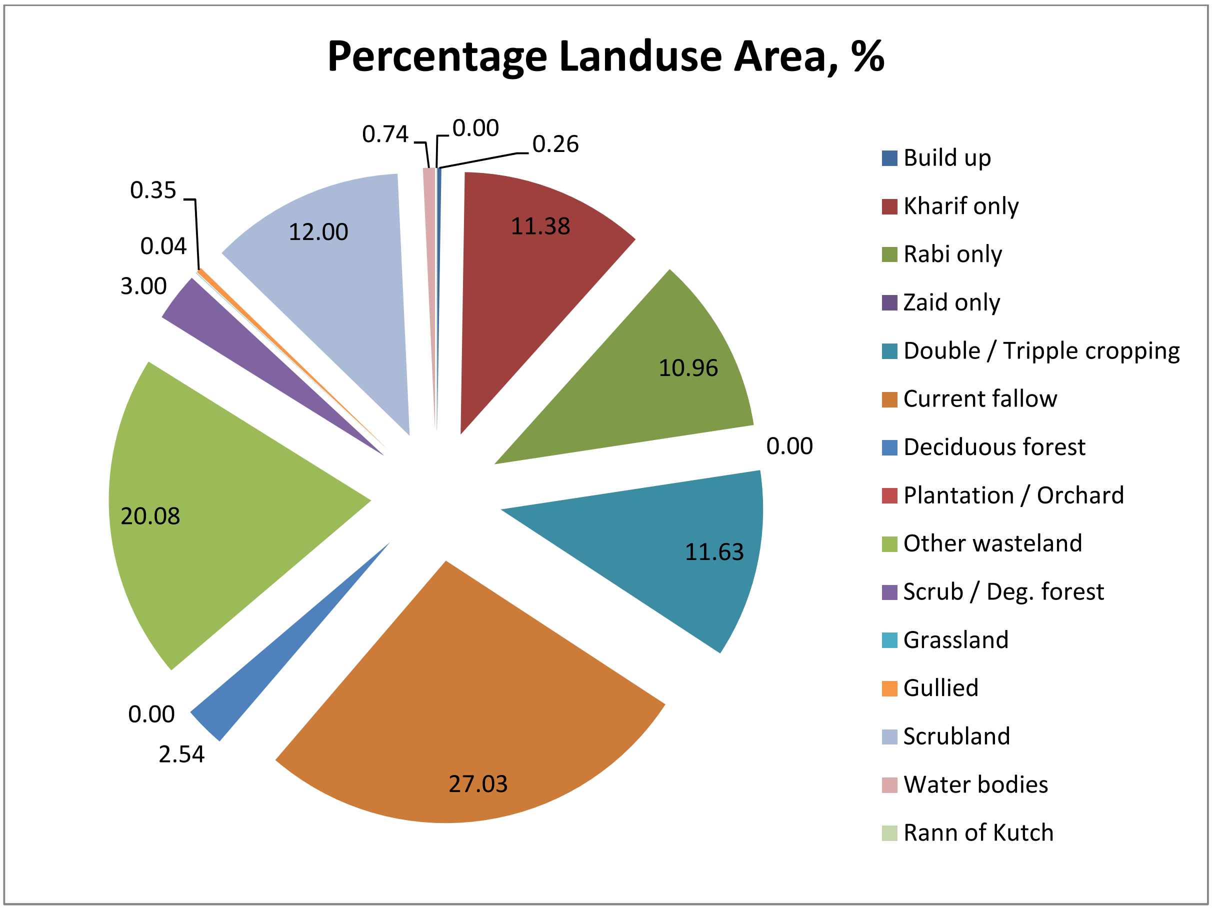
Note: Figures in parentheses are percentages to total cropped area or GCA.

Source: Statistical Cell, Directorate of Agriculture, Rajasthan, Jaipur and official websites of Govt. of Rajasthan and Govt. of India

Table 10.12 Land Uses as Percentage of State Area

Landuse	Area, sq km	Landuse %
Build up	887.43	0.26
Kharif only	38,939.26	11.38
Rabi only	37,528.47	10.96
Zaid only	0.51	0.00
Double / Tripple cropping	39,801.07	11.63
Current fallow	92,500.85	27.03
Deciduous forest	8,701.47	2.54
Plantation / Orchard	1.47	0.00
Other wasteland	68,712.40	20.08
Scrub / Deg. forest	10,269.21	3.00
Grassland	123.80	0.04
Gullied	1,207.40	0.35
Scrubland	41,062.26	12.00
Water bodies	2,527.91	0.74
Rann of Kutch	0.29	0.00

Figure 10.2 Graphical Representation of State Landuse Percentages



Source: Land use data is Land-use/Land-Cover Map of NRSC (2007-2008), Hyderabad (National Remote Sensing Service Centre)

10.7 Agroclimatic Zone-wise Land Use Patterns

Tables 10.13 and 10.14 present land-use area and land-use percentages under each agro-climatic zone.

It is evident from the Table 10.13 that maximum Kharif area is under Agroclimatic Zone Ⅰc having, 8,372 km^2 under Kharif crops which amounts to 10.9 percent of total area under Ⅰc, while it is minimum under ⅢIb with only 818 km^2 area under Kharif crops.

Maximum area for Rabi cropping is under agroclimatic zone Ⅲb, having 9295 km^2 under Rabi crops while it is minimum under zone Ⅰc with 1072 km^2 under Rabi crops.

Maximum area for built-up category is in Agroclimatic zone Ⅲa with 217 km^2 and minimum under zone Ⅳb with 12.95 km^2.

Maximum area for Current fallow category is in Agroclimatic zone Ⅰa with 17,652 km^2 and minimum under zone Ⅳb with 2780 km^2.

Area under Double\triple cropping is highest in zone Ⅰb with 7516 km^2 while minimum under Ⅰa with only 949 km^2 under double\triple cropping.

From Table 10.13 it can be observed that Current Fallow has the maximum share of area in agroclimatic zones Ⅰa, Ⅱa, Ⅱb, Ⅲa, Ⅳa, and Ⅳb, while it is double or triple-cropping in zones Ⅰb and Ⅴ, respectively. "Other wasteland" is dominant in ACZ Ⅰc while Rabi is dominant in Zone Ⅲb.

Table 10.13 Agroclimatic Zone-wise Landuse Area, km^2

Landuse	Agroclimatic Zone									
	Ⅰa	Ⅰb	Ⅰc	Ⅱa	Ⅱb	Ⅲa	Ⅲb	Ⅳa	Ⅳb	Ⅴ
Built up	115.2	61.5	109.5	100.3	21.1	217.1	79.1	73.5	13.0	97.2
Current fallow	17,652.5	3,656.0	14,137.6	11,290.1	11,102.5	13,181.5	5,083.8	9,771.5	2,780.2	3,898.3
Deciduous forest	2.2	8.3	5.8	134.8	343.8	378.9	1,092.9	3,695.6	1,122.2	1,917.8
Double / triple	949.8	7,516.9	2,311.6	6,589.5	3,648.2	2,451.2	2,789.8	5,326.6	2,018.9	6,149.4
Grassland	0.0	0.0	123.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gullied	0.2	0.0	0.0	21.2	0.1	131.6	495.2	0.9	0.0	558.1
Kharif only	2,308.3	2,015.3	8,372.6	7,540.6	5,492.3	2,468.2	818.2	6,061.3	1,644.0	2,208.4
Other wasteland	13,940.1	2,625.6	26,232.9	5,491.9	4,953.3	2,886.8	1,998.6	5,004.2	1,402.8	4,186.9
Plantation/orchard	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
Rabi only	1,113.8	3,066.2	1,072.0	3,114.1	4,003.6	5,736.5	9,295.9	4,047.5	1,387.8	4,664.2
Rann of Kutch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scrub/Deg. forest	16.8	5.6	1.6	522.7	687.7	759.9	2,076.1	2,545.1	1,229.3	2,422.3
Scrubland	9,553.6	1,332.4	24,226.0	2,187.3	1,304.8	984.8	550.1	482.4	99.9	330.8
Water bodies	41.2	299.4	366.7	53.1	130.2	296.9	113.9	533.8	300.0	392.4
Zaid only	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Total Area	45,693.5	20,586.8	76,960.0	37,045.4	31,687.6	29,493.3	24,395.3	37,542.2	11,998.1	26,825.8

Table 10.14 Agroclimatic Zone-wise Landuse Percentage with Respect to Agroclimatic Zone Area, %

Landuse	Agroclimatic Zone									
	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V
Built-up	0.3	0.3	0.1	0.3	0.1	0.7	0.3	0.2	0.1	0.4
Current fallow	38.6	17.8	18.4	30.5	35.0	44.7	20.8	26.0	23.2	14.5
Deciduous forest	0.0	0.0	0.0	0.4	1.1	1.3	4.5	9.8	9.4	7.1
Double / triple	2.1	36.5	3.0	17.8	11.5	8.3	11.4	14.2	16.8	22.9
Grassland	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gullied	0.0	0.0	0.0	0.1	0.0	0.4	2.0	0.0	0.0	2.1
Kharif only	5.1	9.8	10.9	20.4	17.3	8.4	3.4	16.1	13.7	8.2
Other wasteland	30.5	12.8	34.1	14.8	15.6	9.8	8.2	13.3	11.7	15.6
Plantation/orchard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi only	2.4	14.9	1.4	8.4	12.6	19.5	38.1	10.8	11.6	17.4
Rann of Kutch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scrub/Deg. forest	0.0	0.0	0.0	1.4	2.2	2.6	8.5	6.8	10.2	9.0
Scrubland	20.9	6.5	31.5	5.9	4.1	3.3	2.3	1.3	0.8	1.2
Water bodies	0.1	1.5	0.5	0.1	0.4	1.0	0.5	1.4	2.5	1.5
Zaid only	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* *Source*: Land-use/Land-Cover Map (2007-2008) of NRSC, Hyderabad (National Remote Sensing Service Centre)

Agroclimatic Zone-wise Landuse maps are presented in Volume 3 of this report.

10.8 Wastelands, Including Ravines

A total of 27.4 per cent of the State's land area is wasteland of different categories as shown in Table 10.15. District-wise and Agroclimatic Zone-wise different wasteland categories are shown in Table 10.16 and 10.17, respectively.

Table 10.15 Wasteland Categories in Rajasthan

Category	Area, km^2	% of Total Wasteland	% of Total State Area
Gullied and/or ravinous land-Medium	1020.18	1.09	0.298
Gullied and/or ravinous land-Deep	864.76	0.92	0.253
Land with Dense Scrub	23661.70	25.26	6.914
Land with Open Scrub	14619.38	15.60	4.272
Waterlogged and Marshy land-Permanent	64.86	0.07	0.019
Waterlogged and Marshy land-Seasonal	54.95	0.06	0.016
Land affected by salinity/alkalinity-Moderate	347.13	0.37	0.101
Land affected by salinity/alkalinity-Strong	269.13	0.29	0.079

Category	Area, km^2	% of Total Wasteland	% of Total State Area
Under utilised/degraded notified forest land-Scrub dominated	11365.81	12.13	3.321
Under utilised/degraded notified forest land-Agriculture	854.35	0.91	0.250
Degraded pastures/grazing land	3918.44	4.18	1.145
Sands-Riverine	196.69	0.21	0.057
Sands-Desertic	4655.91	4.97	1.360
Sands-Semi stabilised- Stabilised >40m	11188.21	11.94	3.269
Sands-Semi stabilised- Stabilised Moderate High 15-40m	15586.45	16.64	4.554
Mining wastelands	106.85	0.11	0.031
Industrial wastelands	9.07	0.01	0.003
Barren rocky area	4905.74	5.24	1.433
Total	93689.61	100.00	27.375

Source: Wastelands Atlas of India

Table 10.16 District-wise Wasteland Categories in Rajasthan, Km^2

S. No.	Wasteland Categories	Ajmer	Alwar	Barmer	Banswara	Baran	Bharatpur	Bhilwara	Bikaner	Bundi	Chittaurgarh	Churu	Dausa	Dholpur	Dungarpur	Ganganagar	Hanumangarh	Jaipur
1	Gullied and/or ravinous land-Medium	0.09	56.69	0.00	0.00	78.30	0.00	0.00	59.16	99.29	0.00	0.00	73.49	68.06	0.00	0.00	0.00	3.31
2	Gullied and/or ravinous land-Deep	0.00	67.94	20.22	0.00	100.47	0.00	0.00	37.25	210.29	0.00	0.00	33.23	120.08	0.00	0.00	0.00	17.89
3	Land with Dense Scrub	654.08	449.93	1032.84	150.80	191.44	193.16	1618.22	1430.39	247.19	627.64	52.82	129.78	315.96	371.09	21.95	13.66	181.24
4	Land with Open Scrub	910.43	83.24	384.68	146.14	131.87	58.70	768.28	265.73	37.20	320.66	343.38	93.33	83.08	552.60	89.39	33.61	874.92
5	Waterlogged and Marshy land-Permanent	8.31	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	1.32	0.00	0.00	0.00	0.00	5.00	10.10
6	Waterlogged and Marshy land-Seasonal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.97	1.40	0.00
7	Land affected by salinity / alkalinity-Moderate	11.98	0.20	123.12	0.00	0.00	0.25	0.00	0.00	0.00	1.84	14.71	0.17	0.00	0.00	0.00	0.00	19.12
8	Land affected by salinity / alkalinity-Strong	19.9	0.00	9.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.15	0.00	0.00	0.00	0.00	39.87
9	Underutilised / degraded notified forestland-Scrub dominated	210.79	111.10	124.69	559.71	1197.68	57.07	363.48	70.87	770.48	646.09	0.00	75.97	297.98	324.88	0.00	23.12	385.51
10	Underutilised / degraded notified forestland-Agriculture	0.00	40.59	0.75	23.10	130.61	0.19	9.11	0.00	0.00	132.65	0.00	1.24	56.96	18.22	0.00	0.00	0.00
11	Degraded pastures / grazing land	128.01	0.00	279.09	20.97	106.82	0.00	324.26	485.71	27.20	36.62	128.12	15.10	0.00	27.97	0.00	21.46	55.98
12	Sands-Riverine	0.08	0.35	0.00	0.00	46.52	6.94	0.00	0.00	0.00	0.00	0.00	0.90	0.15	0.00	0.00	0.00	23.23
13	Sands-Desertic	19.14	0.08	402.27	0.00	0.00	6.04	0.08	1111.56	0.35	0.00	58.42	0.48	0.00	0.00	154.59	330.54	97.69
14	Sands-Semi stabilised-Stabilised>40m	0.00	0.00	1728.70	0.00	0.00	0.00	0.00	1278.94	0.00	0.00	0.00	0.00	0.00	0.00	1088.21	20.44	0.00
15	Sands-Semi stabilised- Stabilised Moderate High15-40m	0.00	0.00	2598.27	0.00	0.00	0.00	0.00	5907.50	0.00	0.00	109.99	0.00	0.00	0.00	171.83	0.00	0.00

S. No.	Wasteland Categories	Ajmer	Alwar	Barmer	Banswara	Baran	Bharatpur	Bhilwara	Bikaner	Bundi	Chittaurgarh	Churu	Dausa	Dholpur	Dungarpur	Ganganagar	Hanumangarh	Jaipur
16	Mining wastelands	3.37	0.75	1.95	3.30	0.00	1.41	2.65	0.00	0.41	3.61	0.04	0.72	0.22	2.23	0.00	0.00	3.2
17	Industrial wastelands	0.00	0.00	0.00	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	2.57	0.00	0.00
18	Barren rocky area	182.53	273.70	299.060	91.55	35.27	196.08	206.16	19.63	88.81	71.60	4.94	26.70	20.50	52.80	0.00	0.00	80.79
	Total	2148.71	1084.57	7005.57	995.87	2018.98	579.25	3304.56	10667.11	1481.22	1840.71	714.13	451.26	962.99	1349.93	1531.51	449.23	1792.85

Table 10.16 Continued.......

S. No.	Wasteland Categories	Jaisalmer	Jalore	Jhalawar	Jhunjhunu	Jodhpur	Karauli	Kota	Nagaur	Pali	Pratapgarh	Rajsamand	Sikar	Sirohi	Sawai Madhopur	Tonk	Udaipur	Total
1	Gullied and/or ravinous land-Medium	0.00	51.89	19.71	1.42	11.72	134.53	96.61	0.00	14.35	0.00	0.00	21.43	42.62	114.95	0.83	0.00	1020.18
2	Gullied and/or ravinous land-Deep	0.00	20.42	0.26	27.46	0.00	26.95	156.24	0.00	0.00	0.00	0.00	2.64	10.74	9.36	3.32	0.00	864.76
3	Land with Dense Scrub	8352.40	233.51	731.81	30.23	439.60	310.24	238.47	291.82	1188.03	357.36	1478.24	50.38	526.85	163.49	324.15	1262.93	23661.70
4	Land with Open Scrub	3870.31	80.84	374.63	324.37	945.42	60.69	19.84	289.53	361.50	244.72	328.08	392.10	400.07	156.77	269.22	1324.05	14619.38
5	Waterlogged and Marshy land-Permanent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.05	0.00	0.00	0.00	0.09	1.62	0.00	0.00	0.00	64.86
6	Waterlogged and Marshy land-Seasonal	15.33	0.00	0.00	0.00	27.57	0.00	0.00	0.00	7.01	0.00	0.00	0.67	0.00	0.00	0.00	0.00	54.95
7	Land affected by salinity / alkalinity-Moderate	11.36	11.91	0.00	0.00	48.97	0.00	0.00	18.09	77.78	0.70	0.00	6.93	0.00	0.00	0.00	0.00	347.13
8	Land affected by salinity / alkalinity-Strong	40.67	36.66	0.00	0.00	6.18	0.00	0.00	102.56	7.72	0.00	0.00	4.48	0.00	0.62	0.00	0.00	269.13
9	Underutilised / degraded notified forestland-Scrub dominated	145.87	161.06	604.36	169.99	57.53	1121.07	521.43	127.64	197.16	416.21	41.21	309.74	504.43	388.69	102.92	1277.08	11365.81
10	Underutilised / degraded notified forestland-Agriculture	0.04	0.00	12.83	0.00	0.00	243.21	0.00	0.00	4.16	59.72	10.66	0.00	14.84	15.14	0.00	80.33	854.35

S. No.	Wasteland Categories	Jaisalmer	Jalore	Jhalawar	Jhunjhunu	Jodhpur	Karauli	Kota	Nagaur	Pali	Pratapgarh	Rajsamand	Sikar	Sirohi	Sawai Madhopur	Tonk	Udaipur	Total
11	Degraded pastures / grazing land	85.98	286.88	16.15	56.71	661.95	1.38	6.08	528.26	395.64	19.52	30.73	68.08	50.28	11.68	4.18	37.63	3918.44
12	Sands-Riverine	0.00	0.03	0.00	15.48	4.10	0.00	0.34	0.00	69.59	0.00	0.09	19.85	4.51	2.59	1.94	0.00	196.69
13	Sands-Desertic	528.99	285.73	0.00	19.21	1084.12	0.05	0.00	327.84	8.87	0.00	0.00	178.00	33.16	8.54	0.16	0.00	4655.91
14	Sands-Semi stabilised-Stabilised>40m	6905.69	20.57	0.00	0.00	145.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11188.21
15	Sands-Semi stabilised- Stabilised Moderate High15-40m	5058.99	132.30	0.00	0.00	1349.97	0.00	0.00	248.36	0.00	0.00	0.00	0.00	9.24	0.00	0.00	0.00	15586.45
16	Mining wastelands	0.84	0.91	3.30	0.00	20.59	0.56	0.53	4.27	5.85	3.71	12.52	0.12	4.97	0.36	0.17	24.29	106.85
17	Industrial wastelands	0.00	0.61	0.00	0.00	0.99	0.00	0.00	0.00	1.37	0.11	0.00	0.00	2.08	0.00	0.00	0.90	9.07
18	Barren rocky area	1228.13	173.3	13.90	32.69	500.21	55.44	11.32	92.67	289.24	56.73	392.05	28.33	117.27	12.33	22.49	229.52	4905.74
	Total	26244.6	1496.62	1776.95	677.56	5304.58	1954.12	1050.86	2069.09	2628.27	1158.78	2293.58	1082.84	1722.68	884.52	729.38	4236.73	93689.61

Source: Wastelands Atlas of India

Table 10.17 Agroclimatic Zone-wise Wasteland Categories in Rajasthan, Km^2

S. No.	Wasteland Categories	Ia	Ib	Ic	IIa	IIb	IIIa	IIIb	IVa	IVb	V	Total
1	Gullied and/or ravinous land-Medium	9.93	-	59.16	22.85	94.10	67.02	384.52	28.87	-	353.73	1,020.18
2	Gullied and/or ravinous land-Deep	18.74	-	37.25	30.10	28.47	49.60	224.30	4.17	-	472.13	864.76
3	Land with Dense Scrub	1,330.05	35.61	9,814.18	393.86	1,886.26	1,252.69	1,366.60	5,224.72	863.74	1,493.99	23,661.70
4	Land with Open Scrub	1,157.94	123.00	4,340.11	1,145.31	859.27	2,109.73	374.49	2,870.97	993.45	645.12	14,619.38
5	Waterlogged and Marshy land-Permanent	-	5.00	1.15	38.68	0.99	18.19	-	0.85	-	-	64.86
6	Waterlogged and Marshy land-Seasonal	23.37	4.37	15.33	0.67	11.21	-	-	-	-	-	54.95
7	Land affected by salinity / alkalinity-Moderate	155.64	-	20.10	30.99	106.14	30.92	0.47	2.52	0.34	-	347.13
8	Land affected by salinity / alkalinity-Strong	14.44	-	40.90	107.20	46.05	59.36	0.32	0.54	-	0.32	269.13
9	Underutilised / degraded notified forestland-Scrub dominated	164.35	23.12	216.74	607.37	684.70	758.44	1,784.70	2,573.02	1,257.15	3,296.22	11,365.81
10	Underutilised / degraded notified forestland-Agriculture	0.70	-	0.04	-	13.29	1.06	348.39	258.36	81.19	151.32	854.35
11	Degraded pastures / grazing land	819.79	21.46	647.83	705.03	834.54	197.62	9.18	457.20	63.47	162.33	3,918.44
12	Sands-Riverine	3.48	-	-	35.33	73.00	26.02	8.81	1.84	-	48.21	196.69
13	Sands-Desertic	1,291.80	485.13	1,675.27	548.75	509.47	116.88	10.34	13.47	-	4.79	4,655.91
14	Sands-Semi stabilised- Stabilised>40m	1,725.97	1,108.65	8,184.63	-	168.96	-	-	-	-	-	11,188.21
15	Sands-Semi stabilised- Stabilised Moderate High15-40m	3,552.83	171.83	11,031.86	292.98	533.36	-	-	3.59	-	-	15,586.45
16	Mining wastelands	19.26	-	0.86	4.41	13.08	7.26	3.22	43.78	10.55	4.43	106.85
17	Industrial wastelands	0.84	2.57	-	-	3.40	-	-	1.64	0.61	-	9.07
18	Barren rocky area	701.21	-	1,250.70	155.69	632.35	303.69	555.52	948.41	202.45	155.72	4,905.74
	Total	10,990.33	1,980.74	37,336.12	4,119.21	6,498.65	4,998.48	5,070.85	12,433.95	3,472.97	6,788.31	93,689.61

Source: Wastelands Atlas of India

Sand covers ~34% of the total wastelands in the State. While all the 11 western districts have different sands categories as a dominating wasteland category, districts falling along the Aravalli hill ranges and the Vindhyas, have degraded forests or scrub land with or without scrubs and barren rocky areas.

Programs for development of cultivable land have helped in reducing the area classified as cultivable wastelands and increasing the production of various crops. The reduction in areas under cultivable wastelands during various Plan periods is given in Table 10.18.

Table 10.18 Area Under Cultivable Wastelands

Five Year Plan	Average Area Under Cultivable Wasteland, 000 ha
First	N A
Second	70.78
Third	65.61
Fourth	60.24
Fifth	64.89
Sixth	61.22
Seventh	58.15
Eighth	51.89
Ninth	50.17
Tenth	45.73

Source: Rajasthan development report, India Planning Commission.

A coordinated watershed approach is needed to prepare a perspective plan for the development of cultivable and other wasteland, involving the departments of Watershed and Soil Conservation, Agriculture, Horticulture and Forestry.

Bundi, Kota, Dholpur, Baran and Karauli are the top five districts having the bulk of ravenous areas. The area along the banks of Chambal and its tributaries namely Kali Sindh, Parvati, Parwan, Mej, Banas, Morel, Gambhir, Banganga etc. suffer from the problem of land degradation leading to ravenous conditions. Ravines have an adverse effect on agro-economical activities. Due to lack of effective measures of management and reclamation of ravines, they have spread to adjoining arable lands as well. It has been estimated that the rate of encroachment of ravines on arable lands has ranged from 0.50 to 1.07 per cent per year in different situations. About 49% of the ravenous area is under the Government, 40% are privately owned and remaining 9% are the property of Gram Panchayats.

10.9 Management of Ravenous Areas

District-wise and Agroclimatic Zone-wise areas under ravines in Rajasthan are presented in the Table 10.19 and 10.20, respectively.

Table 10.19 District-wise Area under Ravines

District	Area, Km^2	Percent
Ajmer	0.09	0.00
Alwar	124.63	6.61
Barmer	20.22	1.07
Banswara	0.00	0.00
Baran	178.77	9.48
Bharatpur	59.41	3.15
Bhilwara	12.32	0.65
Bikaner	96.41	5.11
Bundi	309.58	16.42
Chittaurgarh	0.00	0.00
Churu	0.00	0.00
Dausa	106.72	5.66
Dholpur	188.14	9.98
Dungarpur	0.00	0.00
Ganganagar	0.00	0.00
Hanumangarh	0.00	0.00
Jaipur	21.20	1.12
Jaisalmer	0.00	0.00
Jalore	72.31	3.84
Jhalawar	19.97	1.06
Jhunjhunu	28.88	1.53
Jodhpur	11.72	0.62
Karauli	161.48	8.57
Kota	252.85	13.41
Nagaur	0.00	0.00
Pali	14.35	0.76
Pratapgarh	0.00	0.00
Rajsamand	0.00	0.00
Sikar	24.07	1.28
Sirohi	53.36	2.83
Sawai Madhopur	124.31	6.59
Tonk	4.15	0.22
Udaipur	0.00	0.00
Total	1884.94	100.00

Source: Wastelands Atlas of India

Table 10.20 Agroclimatic Zone-wise Area under Ravines

Agroclimatic Zones	Area, Km^2	Percent
Ia	28.68	1.52
Ib	0.00	0.00
Ic	96.41	5.11
IIa	82.24	4.36

Agroclimatic Zones	Area, Km^2	Percent
IIb	89.92	4.77
IIIa	116.62	6.19
IIIb	560.74	29.75
IVa	136.63	7.25
IVb	0.00	0.00
V	773.70	41.05
Total	1,884.94	100.00

Source: Wastelands Atlas of India

A two-fold strategy is needed for improving and managing ravines, one for Government-owned land and Gram Panchayat land, and another for privately-owned land. The government-owned land should be put under permanent vegetation and the government should manage the area for at least five years. The areas can then be handed over to adjoining Gram Panchayat or village communities to look after and retain earnings for their own community works. A similar approach would be needed for Gram Panchayat land. Bankable watershed development projects could be formulated for privately-owned land whose owners mobilise their own finance. The benefits would go entirely to the owner. Land, if it is of viable size, could be given to individuals on payment and a loan-cum-subsidy scheme could be developed with assistance from the Centre. All restrictions on agro-forestry, marketing, processing, etc. should be removed.

10.10 Agro Forestry

Agro forestry is an important activity in watershed development and management. During the Eighth and Ninth Five-Year Plans, seedlings were raised in departmental nurseries for distribution to farmers for plantation. While the program needs to be continued, the nurseries should be promoted as commercial ventures, with subsidy-cum-loans to entrepreneurs. Tree plantation under agro forestry is recommended for wasteland development programme.

11. Impact of Change in Weather and Future Strategies

11.1 Impact of Change in Weather Parameters on Cropping Pattern, Productivity and Water Resources

Trend analysis shows that there is a significant positive trend in the both mean maximum temperature and minimum temperature, thereby increasing the concern for crops and water conservation. Increased temperature may shorten the length of growing periods and increase in crop water demand resulting in reduction of yield. Increase in evaporation may affect the open water bodies or storage structures. Increase in temperature with long period of dry spells may affect the soil moisture status leading to drought like situation.

Based on the results of temporal trend analysis of various weather parameters the impacts on cropping pattern, productivity and water resources for various Agroclimatic zones are given below.

ACZ Ia

- Three entities namely, highest maximum temperature, wind speed and relative humidity show decreasing trend in this ACZ.
- The possible impact of this trend can be reduction in the evapotranspiration and thereby the crop water requirements in this ACZ. The prevailing cropping pattern bajra in kharif and mustard and isabgol in rabi may not have significant change however productivity of crops may be affected negatively.
- This shall also imply that there is a general improvement in the water resource availability in this ACZ, which can be used for storage by constructing water harvesting structures.

ACZ Ib

- Three entities namely, highest maximum temperature, wind speed and relative humidity show decreasing trend whereas two of the entities i.e., rainfall of June and mean minimum temperature show increasing trend in this ACZ.
- The possible impact of the decreasing trend in the highest maximum temperature, wind speed and relative humidity can be reduction in the evapotranspiration and thereby the crop water requirements. This will have less impact on prevailing cropping pattern jowar and guar in kharif and mustard and wheat in rabi however productivity of crops may be affected negatively.
- The increase in the rainfall of June can be useful but this advantage may be lost due to the increase in the mean minimum temperature that shall result in increase in the evapotranspiration in this ACZ. However, for a specific crop the ET might not increase since the higher temperature shall result in reduced ET because of the reduction in the crop growth period and thereby the effective crop ET.
- The overall likely impact on the water resources of the ACZ shall be almost not much change overall since there is some increase in the precipitation but the impact shall be compensated by the increased ET demand.

ACZ Ic

- Two entities i.e. highest maximum temperature and sunshine hours show decreasing trend while three entities i.e. rainfall of June, mean minimum temperature and lowest minimum temperature show increasing trend in this ACZ.
- The possible impact of the decreasing trend in the highest maximum temperature and sunshine hours can be reduction in the evapotranspiration and thereby the crop water requirements. This will have less impact on prevailing cropping pattern guar and bajra in kharif and gram in rabi but productivity of crops may decline.
- The increase in the rainfall of June can be useful but this advantage may be lost due to the increase in the mean minimum and the lowest minimum temperature that shall result in increase in the evapotranspiration in this ACZ. However, for a specific crop the ET might not increase since the higher temperature shall result in reduced ET because of the reduction in the crop growth period and thereby the effective crop ET.

- This shall also imply that there is a general improvement in the water resource availability in this ACZ.

ACZ IIa

- There is an increasing trend in rainfall of June and mean minimum temperature in this ACZ.
- A decreasing trend in evaporation has been observed for this ACZ. This will have less impact on prevailing cropping pattern bajra in kharif and wheat and gram in rabi.
- The decreasing trend in the evaporation can be on account of the changes in many other weather parameters (though not significant individually) that in turn influence evaporation.
- The increase in the rainfall of June can be useful but this advantage may be negated due to the increase in the mean minimum temperature that shall result in increase in the evapotranspiration in this ACZ. However, for a specific crop the ET might not increase since the higher temperature shall result in reduced ET because of the reduction in the crop growth period and thereby the effective crop ET.
- The overall likely impact on the water resources of the ACZ shall be almost not much change overall since there is some increase in the precipitation but the impact shall be compensated by the increased ET demand.

ACZ IIb

- Two entities i.e. mean maximum temperature and lowest minimum temperature shows increasing trend while relative humidity shows decreasing trend in this ACZ.
- Possible impact of increased mean maximum and lowest minimum temperature along with reduced relative humidity shall be enhanced evapotranspiration and thus lowering of the crop durations. This might entail reduction in crop yields. Prevailing cropping pattern bajra, maize and sesamum in kharif and mustard and wheat may not have significant impact.
- This shall also imply that there is a general reduction in the water resource availability in this ACZ.

ACZ IIIa

- Only one entity shows significant trend i.e. mean maximum temperature, which shows increasing trend in this ACZ.
- Possible impact of increased mean maximum temperature shall be enhanced evapotranspiration and thus lowering of the crop durations. This might entail reduction in crop yields however prevailing cropping pattern jowar and bajra in kharif and wheat in rabi may not have significant impact.
- This shall also imply that there is a general reduction in the water resource availability in this ACZ.

ACZ IIIb

- Two entities i.e. rainfall in June and relative humidity shows increasing trend while three entities i.e. rainfall in August, mean maximum temperature and highest maximum temperature shows decreasing trend in this ACZ.

- The combined effect of reduced temperature and increased relative humidity shall be reduction in evapotranspiration. This will have an impact on prevailing cropping pattern of bajra in kharif and mustard and wheat in rabi as the bajra cropping may reduce similarly productivity of crops may also be affected negatively.
- The increase in June rainfall can be beneficial for the timely sowing and reduced evapotranspiration can result in slight improvement in the crop yields (of course depending on many other factors such as crop species etc.).
- This shall also imply that there is a general improvement in the water resource availability in this ACZ.

ACZ IVa

- Four entities i.e. rainfall in July, mean maximum temperature, mean minimum temperature and lowest minimum temperature shows increasing trend in this ACZ.
- Resultant effect could be increase in evapotranspiration with reduction in crop duration. This will lead to early maturity and reduction in crop yield. Prevailing cropping pattern maize and soybean in kharif and wheat in rabi will not be significantly affected.
- The overall likely impact on the water resources of the ACZ shall be almost not much change overall since there is some increase in the precipitation but the impact shall be compensated by the increased ET demand.

ACZ IVb

- In this ACZ one entity i.e. rainfall in July shows increasing trend while highest maximum temperature shows decreasing trend.
- This can be beneficial with reduced evapotranspiration and increased crop yield, prevailing cropping pattern of maize and soybean in kharif and wheat in rabi will not be significantly affected.
- This shall also imply that there is a general improvement in the water resource availability in this ACZ.

ACZ V

- In this ACZ two entities i.e. rainfall in August and highest maximum temperature shows decreasing trend while two entities i.e. mean minimum temperature and lowest minimum temperature shows increasing trend.
- Evapotranspiration will increase to some extent, but might need supplementary irrigation due to decreasing rainfall in August. Cropping pattern of soybean and bajra in kharif and mustard, wheat and coriander in rabi will not be significantly affected however, crops productivity may be affected.
- This shall also imply that there is a general reduction in the water resource availability in this ACZ.

11.2 Possible reasons for Change in weather in various ACZ's

The possible reasons mentioned here are stated after general overview of the area and their various sectors that may affect the weather parameters.

ACZ Ia

Change in weather parameters in ACZ Ia may be due to following main factors:

- Increase in Vehicular pollution.
- Increase in Industrial pollution.
- Excessive mining of minerals like Gypsum and Lignite in district of Barmer and stone mining in areas of Jodhpur.
- Land degradation due to mining activities.
- Loss of green cover.

ACZ Ib

Change in weather parameters in ACZ Ib may be due to following main factors:

- Increase in green cover.

ACZ Ic

Change in weather parameters in ACZ Ic may be due to following main factors:

- Increase in Vehicular pollution.
- Increase in Industrial pollution.
- Increase in desertification.

ACZ IIa

Change in weather parameters in ACZ IIa may be due to following main factors:

- Increase in Vehicular pollution.
- Increase in Industrial pollution.
- Loss of green cover.
- Mining activities like in areas of Makrana.
- Growth in small scale cement industries in areas of Sikar, Churu and Nagaur.

ACZ IIb

Change in weather parameters in ACZ IIb may be due to following main factors:

- Increase in Vehicular pollution.
- Loss of green cover.
- Land degradation.
- Industrial pollution due to increase in small scale industries like textiles in areas near Pali and stone cutting, polishing industries in Jalore.

ACZ IIIa

Change in weather parameters in ACZ IIIa may be due to following main factors:

- Rapid industrialization in districts of Jaipur, Ajmer and Tonk.
- Increase in Vehicular pollution.
- Increase in Industrial pollution.

- Excessive mining in and near Aravalli hills.
- Loss of green cover and forest cover.
- Land degradation.

ACZ IIIb

Change in weather parameters in ACZ IIIb may be due to following main factors:

- Increase in green cover.
- Increase in rainfall and thus cloud cover over the area thereby decreasing the mean maximum temperature.

ACZ IVa

Change in weather parameters in ACZ IVa may be due to following main factors:

- Rapid industrialization.
- Excessive mining in districts of Udaipur and Bhilwara.
- Excessive generation of hazardous wastes from industries situated in district of Udaipur and Bhilwara.
- Deforestation.
- Land degradation due to mining activities.
- Increase in Vehicular pollution.
- Increase in Industrial pollution.
- Loss of green cover.

ACZ IVb

Change in weather parameters in ACZ IVb may be due to following main factors:

- There is insignificant change in mean maximum and mean minimum temperature and significant decrease in highest maximum temperature. Scientific reasoning for this change in this ACZ is difficult to establish.

ACZ V

Change in weather parameters in ACZ V may be due to following main factors:

- Rapid industrialization.
- Excessive mining.
- Increase in Vehicular pollution.
- Increase in Industrial pollution.
- Loss of green cover.
- Increase in urban areas.

11.3 ACZ wise futuristic strategies in view of change in weather

Based on the weather analysis and referring to the District contingency plan, Climate resilient technologies developed by NICRA (National Initiative on Climate Resilient Agriculture) the following inferences are drawn:

ACZ Ia

- The prevailing cropping pattern of bajra in kharif and mustard and isabgol in rabi shall continue to fulfil the future needs.

- Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.
- Practicing inter-cropping / mixed cropping.
- Practicing dry land farming system.
- Soil mulching.
- Harvesting the crops for fodder in case of drought.
- Promotion of perennial component (agro-forestry).

ACZ Ib

- The prevailing cropping pattern of jowar and guar in kharif and mustard and wheat in rabi needs to be continued to cater the future needs.
- Apply crop and soil management practices to harness the water during excess rainfall.
- Use of sprinkler irrigation.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.

ACZ Ic

- The prevailing cropping pattern of guar and bajra in kharif and gram in rabi shall continue with increased area of guar compensating area of bajra in kharif.
- Apply crop and soil management practices to harness the water in excess rainfall.
- Cultural and management practices that reduce canopy temperature during the seasons with higher air temperatures.
- Strategies for reducing the warming effect over the area by improving vegetative cover and creating sink for greenhouse gases.
- Use of sprinkler irrigation.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.

ACZ IIa

- The prevailing cropping pattern of bajra in kharif and wheat and gram in rabi shall continue to fulfil future needs.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.

- Cultural and management practices that reduce canopy temperature during the seasons with higher air temperatures.
- Strategies for reducing the warming effect over the area by improving vegetative cover and creating sink for greenhouse gases.
- Apply crop and soil management practices to harness the water in excess rainfall.
- Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.

ACZ IIb

- Prevailing cropping pattern of bajra, maize and sesamum in kharif and mustard and wheat in rabi shall continue with increased area of sesamum compensating maize in kharif to fulfil the future requirements.
- Summer ploughing for conserving moisture in the soil.
- Water harvesting tank for terminal drought life saving irrigation.
- Early maturing varieties should be sown.
- Cultural and management practices that reduce canopy temperature during the seasons with higher air temperatures.
- Strategies for reducing the warming effect over the area by improving vegetative cover and creating sink for greenhouse gases.
- Inter culture operation for moisture conservation.
- Use of sprinkler irrigation.

ACZ IIIa

- Prevailing cropping pattern of jowar and bajra in kharif and wheat in rabi shall continue with increased area of bajra compensating jowar in kharif to fulfil future needs.
- Cultural and management practices that reduce canopy temperature during the seasons with higher air temperatures.
- Strategies for reducing the warming effect over the area by improving vegetative cover and creating sink for greenhouse gases.
- Hoeing & weeding to conserve moisture.
- Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.

ACZ IIIb

- The prevailing cropping pattern of bajra in kharif and mustard and wheat in rabi shall continue to fulfil the future requirements.
- Apply crop and soil management practices to harness the water in June month when there is an increase in rainfall and harvest it during August month when the rainfall is showing a decreasing trend.
- Water harvesting structures be constructed with larger catchment area.
    - Roof water harvesting.
    - Renovation of defunct rainwater harvesting structure.

- Use of sprinkler irrigation.

ACZ IVa

- Prevailing cropping pattern of maize and soybean in kharif and wheat in rabi shall continue to fulfil the future needs.
- Cultural and management practices that reduce canopy temperature during the seasons with higher air temperatures.
- Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.
- Strategies for reducing the warming effect over the area by improving vegetative cover and creating sink for greenhouse gases.
- Inter culture operation for moisture conservation.
- Apply crop and soil management practices to harness the water in excess rainfall in the month of July.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.

ACZ IVb

- The prevailing cropping pattern of maize and soybean in kharif and wheat in rabi shall continue to cater the future requirements.
- Crop and soil management practices can be applied to harness excess water in the month of July.
- Use of sprinkler irrigation.
- Water harvesting structures be constructed with larger catchment area.
    - Rainwater harvesting through improved tankas and nadi.
    - Roof water harvesting.
    - In situ moisture conservation: field/ farm bunds.

ACZ V

- Cropping pattern of soybean and bajra in kharif and mustard, wheat and coriander shall continue.
- Rainwater harvesting structures: farm ponds, percolation ponds should be constructed.
- Renovation of defunct community rainwater harvesting structures.
- In situ moisture conservation: broad bed furrow, deep ploughing in summer, bunding of field.
- Recycling of organic matter through pit composting and vermi-composting.
- Use of sprinkler irrigation.

Agroclimatic zone-wise summary of recommendations for irrigation methods considering different weather parameters and cropping pattern is presented in Table 11.1.

Table 11.1 Agroclimatic Zone-wise Summary of Recommendations for Irrigation Methods

Agro-climatic Zone		Mean Daily Wind Speed, km/hr			Mean Daily Relative Humidity, %			Mean Annual Total Evaporation, cm			Mean Daily Maximum Temperature, °C				Mean Daily Minimum Temperature, °C			Mean Annual Rainfall, mm			Cropping Pattern (Major Crops)		Recommendations
		Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	High. Max.	Min.	Max.	Mean	Min.	Max.	Mean	Kharif	Rabi	
Ia	Arid Western	3.3	8.1	5.2	43.9	52.3	47.4	206.9	264.4	232.9	32.8	35.0	34.2	46.4	18.3	20.9	19.5	86.4	567.4	270.2	Bajra	Isabgol, Mustard	Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.
Ib	Irrigated North Western Plain	3.2	5.3	4.1	46.9	57.7	52.9	174.1	222.7	194.3	33.1	34.1	33.5	46.9	18.1	19.4	18.5	110.6	459.3	244.0	Jowar, Guar	Wheat, Mustard	Use of sprinkler irrigation.
Ic	Hyper Arid Irrigated Western Plain Partially	4.4	10.1	6.5	43.5	50.7	46.9	199.7	306.7	247.5	33.6	34.7	34.1	46.4	18.2	20.4	19.5	70.1	501.5	281.4	Guar, Bajra	Gram, Wheat	Use of sprinkler irrigation.
IIa	Transitional Plain of inland drainage	3.6	6.1	4.7	43.8	55.6	48.8	199.3	242.0	214.1	32.6	34.3	33.4	46.3	17.3	20.6	18.9	188.6	819.2	439.4	Bajra	Wheat, Mustard	Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.
IIb	Transitional Plain of Luni Basin	1.9	5.5	3.8	44.7	61.4	52.0	141.1	251.4	199.0	25.9	34.6	32.8	44.5	12.0	20.3	18.4	108.2	1060.0	412.2	Bajra, Maize, Sesamum	Mustard, Wheat	Use of sprinkler irrigation.
IIIa	Semi-Arid Eastern Plain	1.6	7.6	5.3	43.5	53.7	48.5	205.8	228.1	218.3	32.4	33.2	32.8	44.3	18.4	20.7	19.6	205.9	841.8	518.7	Jowar, Bajra	Mustard, Wheat	Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is recommended for vegetables and fruits.
IIIb	Flood Prone Eastern Plain	2.0	6.1	4.4	49.4	55.9	52.5	209.4	224.0	216.7	32.7	33.9	33.2	47.1	18.2	19.4	19.2	284.6	1027.4	618.7	Bajra	Mustard, Wheat	Use of sprinkler irrigation.
IVa	Sub humid Southern Plain	2.3	8.5	4.8	47.1	61.5	52.5	148.8	217.5	197.9	25.9	33.2	32.3	42.1	12.0	20.2	18.2	310.7	1174.0	615.5	Maize, Soybean	Wheat, Mustard	Use of sprinkler irrigation for major crops. Considering significant production of vegetables and fruits from this ACZ, drip irrigation is

Agro-climatic Zone		Mean Daily Wind Speed, km/hr			Mean Daily Relative Humidity, %			Mean Annual Total Evaporation, cm			Mean Daily Maximum Temperature, °C				Mean Daily Minimum Temperature, °C			Mean Annual Rainfall, mm			Cropping Pattern (Major Crops)		Recommendations
		Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	High. Max.	Min.	Max.	Mean	Min.	Max.	Mean	Kharif	Rabi	
																							recommended for vegetables and fruits.
IVb	Humid southern Plain	4.6	7.2	5.1	51.5	54.2	53.3	201.2	222.9	214.3	31.8	33.6	33.0	45.0	17.8	20.8	19.6	363.1	1657.6	782.8	Maize, Soybean	Wheat, Mustard	Use of sprinkler irrigation.
V	Humid South-Eastern Plain	1.4	6.5	4.3	44.1	55.1	51.2	189.5	218.3	206.6	31.8	33.2	32.6	46.3	19.1	21.9	19.9	371.7	1254.7	773.4	Soybean, Bajra	Wheat, Mustard	Use of sprinkler irrigation.

NOTE:

The mean daily wind velocity in various agroclimatic zones of Rajasthan State varies from 1.0 to 13.0 km/hr. During the Rabi season (November to March), mean daily wind velocity ranges from 1.0 to 6.1 km/hr. The literature shows that sprinklers are not found suitable for wind velocities over 16 km/hr. As per the observed wind velocities in different agroclimatic zones during the year sprinklers can be used for all agroclimatic zones of Rajasthan.

It is to be pointed out that above recommendations are being proposed considering the major crops of Rabi season as well as production of vegetables and fruits from the particular agroclimatic zone.

For the design of sprinkler irrigation system for specific area / agroclimatic zone a detailed study is required to determine the pressure range, diameter of nozzles, spacing and area of coverage.

Important References:

1. Sprinkler Systems Design Guide, Netafim USA (http://www.netafimusa.com/files/literature/greenhouse/G221-Sprinkler-Design-Guide.pdf)
2. Potential for Drip and Sprinkler Irrigation in India, A. Narayanamoorthy
3. NABARD, Model Bankable Scheme for Sprinkler Irrigation Systems (www.nabard.org/modelbankprojects/mi_sprinkler.asp)
4. Impact of Drip Irrigation Technology among farmers in Jaipur Region of Rajasthan, R.C. Jitarwal and N. K. Sharma, Indian Res. J. Ext. Edu. 7 (2&3), May & September 2007
5. Jain Irrigation Systems Ltd. (www.jains.com)
6. Efficiency of Irrigation: A Case of Drip Irrigation, Occasional Paper - 45, A. Narayanmoorthy, Department of Economic Analysis and Research, NABARD, Mumbai, 2005
7. Drip and Sprinkler Irrigation in India: Benefits, Potential and Future Directions, A.Narayanmoorthy, Alagappa University, Karaikudi, Tamil Nadu, India, 2009

In addition to change in weather, cropping pattern and productivity are changing with time, influenced by technological advances, irrigation methods, water availability, market conditions and other factors, accordingly a analysis of available data on major crops, areas sown and production obtained has been carried out and trends have been identified and presented in Appendix 14 (Volume 2 of this report).

Table 11.2 summarises the results of the analysis of the present and projected productivity of crops grown in Rajasthan. The ACZ wise present and projected productivity of crops is given in Table 11.3.

Table 11.2 Crop Productivity Projections in Rajasthan, kg/ha

S. No.	Crops		2010*	2020	2040	2060
Kharif						
1	Cereals	Bajra	1,110	1,122	1,390	1,692
2		Jowar	700	763	778	0
3		Maize	1,796	1,832	2,079	2,514
4		Rice	2,025	2,167	2,636	3,400
5	Pulses	Cowpea	529	545	667	769
6		Moong	621	639	695	729
7		Moth	486	521	618	688
8		Urad	737	400	571	692
9	Oilseeds	Ground Nut	1,963	2,086	2,256	3,080
10		Sesamum	408	444	588	806
11		Soyabean	1,461	1,487	1,794	2,144
12	Others	Castor	1,417	1,718	2,435	2,855
13		Cluster Bean	515	517	528	595
Rabi						
14	Cereals	Barley	2,911	4,267	5,583	0
15		Wheat	3,433	3,463	3,965	4,322
16	Pulse	Gram	898	1,011	1,079	1,233
17	Oilseed	Mustard	1,560	1,568	2,120	2,330
18	Others	Coriander	1,106	1,500	2,033	2,541
19		Cumin	348	375	400	407
20		Isabgol	529	560	575	600

*Source: Agricultural Statistics, Year 2010, Department of Agriculture, Rajasthan, Jaipur

Table 11.3 Agroclimatic Zone-wise Crop Productivity Projections in Rajasthan, kg/ha

ACZ	Ia				Ib				Ic				IIa			
Crops	2010*	2020	2040	2060	2010*	2020	2040	2060	2010*	2020	2040	2060	2010*	2020	2040	2060
Bajra	719	766	860	953	911	1,236	1,569	1,832	552	625	771	1,035	1,370	1,428	1,545	1,999
Jowar	709	656	550	445	-	-	-	-	708	666	582	500	1,043	1,097	1,205	1,311
Maize	2,000	-	-	-	1,800	-	-	-	1,857	-	-	-	1,797	-	-	-
Rice	-	-	-	-	3,576	3,629	3,735	3,841	2,027	2,208	2,570	2,930	-	-	-	-
Cowpea	545	501	413	326	667	-	-	-	298	350	356	359	520	526	538	549
Moong	632	559	413	268	532	532	541	546	412	423	439	448	623	579	491	402
Moth	532	483	385	287	435	440	449	479	519	553	621	689	384	401	435	468
Urad	-	-	-	-	736	652	484	318	-	-	-	-	-	-	-	-
Groundnut	1,540	1,564	1,566	1,567	1,846	-	-	-	2,447	2,305	2,021	1,739	1,993	1,985	1,969	1,952
Sesamum	412	428	476	-	497	495	491	486	234	527	-	-	390	-	-	-
Soyabean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Castor	657	662	672	680	1,375	1,377	1,381	1,384	331	338	352	367	1,099	1,031	895	757
Cluster Bean	414	383	321	257	804	835	898	1,013	404	371	305	237	562	597	666	1,154
Barley	2,912	3,151	-	-	3,755	3,751	3,743	3,736	1,801	1,911	2,017	2,074	2,583	3,120	3,781	4,272
Wheat	2,267	2,417	2,629	2,770	4,140	4,169	4,227	4,284	2,928	2,777	2,475	2,175	3,072	3,081	3,099	3,115
Gram	897	871	819	765	757	457	-	-	723	698	648	596	946	959	985	1,041
Mustard	1,215	1,220	1,230	1,237	2,022	1,922	1,722	1,522	1,038	1,004	936	866	1,342	1,318	1,270	1,223
Coriander	1,110	1,136	1,250	1,314	1,167	-	-	-	1,100	1,136	1,151	1,157	1,114	1,177	1,303	-
Cumin	327	324	314	310	-	-	-	-	478	448	388	326	454	420	352	284
Isabgol	510	449	327	206	500	537	564	575	406	394	370	344	588	609	651	693

*Source: Agricultural Statistics, Year 2010, Department of Agriculture, Rajasthan, Jaipur

Table 11.3 Continued…..

ACZ	IIb				IIIa				IIIb			
Crops	2010*	2020	2040	2060	2010*	2020	2040	2060	2010*	2020	2040	2060
Bajra	954	1,020	1,151	1,629	1,389	1,468	1,626	1,803	1,860	1,911	2,290	2,561
Jowar	629	600	542	484	683	767	935	1,515	633	682	768	856
Maize	1,714	1,962	2,458	2,956	1,459	1,360	1,320	-	1,801	1,875	2,023	-
Rice	-	-	-	-	2,000	-	-	-	1,712	1,840	2,533	3,345
Cowpea	454	551	745	938	611	-	-	-	544	-	-	-
Moong	594	546	450	354	715	646	508	369	620	-	-	-
Moth	590	551	473	396	527	-	-	-	485	-	-	-
Urad	736	512	-	-	717	646	504	362	516	549	618	688
Groundnut	1,626	1,592	1,524	1,458	1,810	1,885	2,034	2,303	1,661	1,490	-	-
Sesamum	428	437	455	472	366	362	354	348	476	527	586	621
Soyabean	1,000	1,499	1,721	1,877	1,468	1,418	1,318	1,215	1,462	1,415	1,321	1,225
Castor	1,808	1,707	1,505	1,301	420	436	468	502	1,000	-	-	-
Cluster Bean	635	695	815	933	893	908	938	970	1,012	1,334	-	-
Barley	2,271	-	-	-	3,147	3,240	4,285	5,329	3,465	-	-	-
Wheat	2,010	2,394	3,263	4,475	3,491	3,664	4,987	6,003	4,143	4,267	4,516	4,828
Gram	712	781	856	913	1,155	1,097	980	-	1,425	-	-	-
Mustard	1,230	1,260	1,319	1,468	1,478	1,392	1,220	1,047	1,718	1,686	1,622	1,556
Coriander	1,116	1,351	1,899	2,447	1,106	-	-	-	1,107	-	-	-
Cumin	324	318	297	285	311	308	299	294	500	-	-	-
Isabgol	597	298	-	-	477	472	462	453	500	-	-	-

*Source: Agricultural Statistics, Year 2010, Department of Agriculture, Rajasthan, Jaipur

Table 11.3 Continued…..

ACZ	IVa				IVb				V			
Crops	2010*	2020	2040	2060	2010*	2020	2040	2060	2010*	2020	2040	2060
Bajra	1,149	1,246	1,440	1,939	1,111	1,629	-	-	1,783	1,865	2,504	3,094
Jowar	725	700	648	-	657	-	-	-	996	-	-	-
Maize	1,747	1,781	1,850	2,002	1,752	1,732	1,692	1,653	2,331	2,344	2,370	2,396
Rice	1,382	1,091	-	-	682	694	718	740	2,337	2,312	2,262	2,214
Cowpea	426	490	-	-	522	-	-	-	539	-	-	-
Moong	646	599	505	412	605	-	-	-	622	-	-	-
Moth	514	-	-	-	500	138	120	92	489	-	-	-
Urad	764	688	536	385	501	269	-	-	885	884	882	880
Groundnut	1,463	1,562	1,760	1,956	1,408	1,892	-	-	1,741	-	-	-
Sesamum	444	490	582	676	388	345	-	-	395	455	615	774
Soyabean	1,328	1,288	1,208	1,125	1,248	1,230	1,194	1,157	1,506	1,454	1,350	1,246
Castor	1,806	1,725	1,563	1,400	467	553	766	1,185	-	-	-	-
Cluster Bean	760	712	616	519	673	639	571	501	515	520	530	541
Barley	2,312	2,604	-	-	2,377	-	-	-	2,911	-	-	-
Wheat	3,077	3,406	4,148	4,796	2,016	2,253	2,374	2,454	3,544	3,790	4,425	4,886
Gram	946	988	1,143	-	901	1,051	-	-	1,027	-	-	-
Mustard	1,386	1,374	1,350	1,326	1,559	1,578	1,616	1,657	1,456	1,436	1,396	1,358
Coriander	662	704	788	873	1,091	1,166	1,316	1,467	1,114	1,247	1,377	1,459
Cumin	344	342	331	326	355	352	342	336	231	333	-	-
Isabgol	530	514	482	448	530	522	506	489	529	512	478	443

*Source: Agricultural Statistics, Year 2010, Department of Agriculture, Rajasthan, Jaipur

Crops share in cultivated area in Rajasthan and in different Agroclimatic Zones of Rajasthan is shown in Table 11.4 and 11.5, respectively.

Table 11.4 Crops Share in Cultivated Area in Rajasthan

S. No.	Crops	Area, hectare	Percentage
1	Bajra	5,168,502	24.022
2	Guar	2,581,273	11.997
3	Wheat	2,394,215	11.128
4	Mustard	2,212,339	10.282
5	Moth	1,272,785	5.916
6	Maize	1,096,231	5.095
7	Moong	922,885	4.289
8	Gram	884,358	4.110
9	Soyabean	778,382	3.618
10	Jowar	718,457	3.339
11	Sesamum	598,306	2.781
12	Cotton	444,431	2.066
13	Groundnut	326,032	1.515
14	Medicine and Aeromats	256,227	1.191
15	Coriander	232,139	1.079
16	Isabgol	227,705	1.058
17	Barley	223,406	1.038
18	Cumin	203,855	0.947
19	Rice	150,691	0.700
20	Cowpea	124,407	0.578
21	Castor Seed	117,211	0.545
22	Urad	116,377	0.541
23	Taramira	97,542	0.453
24	Vegetables	80,631	0.375
25	Fenugreek	58,917	0.274
26	Mehandi	40,897	0.190
27	Onion	37,819	0.176
28	Fruits	27,256	0.127
29	Lentil	27,047	0.126
30	Garlic	24,671	0.115
31	Arhar	18,346	0.085
32	Carom	15,483	0.072
33	Chillies	13,812	0.064
34	Fennel	8,755	0.041
35	Potato	8,530	0.040
36	Sugarcane	5,985	0.028
	Total	21,515,905	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

Table 11.5 ACZ-wise Crop Share in Cultivated Area in Rajasthan (2009-2010)

ACZ	Ia			Ib		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
1	Bajra	1,374,114	47.999	Wheat	419,607	22.062
2	Guar	453,093	15.827	Guar	348,175	18.306
3	Moth	359,573	12.560	Cotton	338,553	17.801
4	Moong	127,738	4.462	Mustard	302,524	15.906
5	Cumin	94,495	3.301	Gram	230,309	12.109
6	Isabgol	93,881	3.279	Bajra	57,698	3.034
7	Mustard	78,513	2.743	Barley	48,487	2.549
8	Wheat	59,133	2.066	Moth	42,410	2.230
9	Jowar	54,019	1.887	Rice	33,375	1.755
10	Groundnut	37,837	1.322	Moong	32,985	1.734
11	Sesamum	34,570	1.208	Taramira	12,721	0.669
12	Castor Seed	33,007	1.153	Sesamum	9,730	0.512
13	Vegetables	25,912	0.905	Groundnut	9,475	0.498
14	Onion	13,402	0.468	Fruits	6,786	0.357
15	Cotton	9,352	0.327	Vegetables	2,360	0.124
16	Fruits	3,261	0.114	Sugarcane	2,340	0.123
17	Garlic	3,028	0.106	Castor Seed	2,199	0.116
18	Fenugreek	2,233	0.078	Urad	607	0.032
19	Chillies	1,929	0.067	Jowar	527	0.028
20	Mehandi	1,393	0.049	Potato	345	0.018
21	Fennel	715	0.025	Fenugreek	289	0.015
22	Taramira	695	0.024	Chillies	134	0.007
23	Barley	438	0.015	Arhar	106	0.006
24	Coriander	232	0.008	Garlic	82	0.004
25	Gram	139	0.005	Onion	75	0.004
26	Medicine and Aeromats	75	0.003	Medicine and Aeromats	18	0.001
27	Cowpea	23	0.001	Lentil	12	0.001
28	Maize	15	0.001	Cowpea	-	-
29	Potato	-	-	Maize	-	-
30	Rice	-	-	Coriander	-	-
31	Urad	-	-	Cumin	-	-
32	Arhar	-	-	Isabgol	-	-
33	Soyabean	-	-	Soyabean	-	-
34	Lentil	-	-	Mehandi	-	-
35	Carom	-	-	Fennel	-	-
36	Sugarcane	-	-	Carom	-	-
	Total	2,862,815	100.000	Total	1,901,929	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

Table 11.5 Continued…

ACZ	Ic			IIa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
1	Guar	1,139,097	39.728	Bajra	1,203,013	36.394
2	Bajra	650,981	22.704	Moth	334,943	10.133
3	Moth	454,708	15.859	Guar	332,302	10.053

ACZ	Ic			IIa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
4	Gram	267,890	9.343	Moong	313,833	9.494
5	Groundnut	101,257	3.531	Wheat	256,508	7.760
6	Wheat	80,190	2.797	Mustard	190,559	5.765
7	Mustard	73,604	2.567	Gram	167,869	5.078
8	Isabgol	26,877	0.937	Cowpea	108,069	3.269
9	Moong	22,890	0.798	Medicine and Aeromats	94,329	2.854
10	Cumin	12,745	0.445	Barley	54,673	1.654
11	Fenugreek	9,651	0.337	Jowar	53,816	1.628
12	Barley	7,116	0.248	Isabgol	51,582	1.560
13	Sesamum	5,707	0.199	Groundnut	47,065	1.424
14	Cotton	5,241	0.183	Fenugreek	23,320	0.705
15	Taramira	2,585	0.090	Sesamum	19,967	0.604
16	Medicine and Aeromats	2,109	0.074	Cotton	18,287	0.553
17	Vegetables	1,652	0.058	Cumin	16,415	0.497
18	Castor Seed	1,236	0.043	Onion	11,130	0.337
19	Jowar	1,110	0.039	Vegetables	2,433	0.074
20	Cowpea	321	0.011	Fennel	1,655	0.050
21	Fruits	114	0.004	Taramira	1,081	0.033
22	Rice	63	0.002	Chillies	790	0.024
23	Onion	47	0.002	Fruits	736	0.022
24	Coriander	34	0.001	Garlic	620	0.019
25	Chillies	16	0.001	Arhar	209	0.006
26	Arhar	15	0.001	Castor Seed	169	0.005
27	Maize	-	-	Maize	76	0.002
28	Potato	-	-	Coriander	57	0.002
29	Lentil	-	-	Sugarcane	-	-
30	Fennel	-	-	Potato	-	-
31	Sugarcane	-	-	Mehandi	-	-
32	Urad	-	-	Carom	-	-
33	Soyabean	-	-	Soyabean	-	-
34	Mehandi	-	-	Rice	-	-
35	Garlic	-	-	Urad	-	-
36	Carom	-	-	Lentil	-	-
	Total	2,867,256	100.000	Total	3,305,506	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

Table 11.5 Continued…

ACZ	IIb			IIIa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
1	Bajra	574,590	30.244	Bajra	565,526	26.260
2	Moong	218,706	11.512	Mustard	342,948	15.925
3	Sesamum	187,549	9.872	Jowar	268,894	12.486
4	Guar	157,643	8.298	Wheat	259,408	12.046
5	Jowar	148,788	7.832	Moong	184,010	8.544
6	Mustard	90,361	4.756	Sesamum	138,590	6.435
7	Moth	78,013	4.106	Guar	68,951	3.202

ACZ	IIb			IIIa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
8	Wheat	75,550	3.977	Groundnut	68,465	3.179
9	Cumin	75,303	3.964	Barley	64,668	3.003
10	Castor Seed	69,001	3.632	Maize	52,903	2.457
11	Isabgol	52,130	2.744	Taramira	51,480	2.390
12	Medicine and Aeromats	44,250	2.329	Gram	22,232	1.032
13	Mehandi	39,486	2.078	Urad	14,574	0.677
14	Maize	37,553	1.977	Cowpea	13,233	0.614
15	Groundnut	13,343	0.702	Vegetables	10,562	0.490
16	Fruits	9,411	0.495	Cotton	6,803	0.316
17	Cotton	7,705	0.406	Fenugreek	3,049	0.142
18	Vegetables	5,576	0.293	Cumin	2,885	0.134
19	Onion	2,657	0.140	Moth	2,814	0.131
20	Barley	2,638	0.139	Chillies	2,351	0.109
21	Fennel	2,459	0.129	Medicine and Aeromats	1,991	0.092
22	Cowpea	1,721	0.091	Fennel	1,948	0.090
23	Taramira	1,160	0.061	Fruits	1,911	0.089
24	Chillies	1,149	0.060	Onion	1,749	0.081
25	Fenugreek	1,030	0.054	Lentil	709	0.033
26	Urad	816	0.043	Arhar	318	0.015
27	Garlic	554	0.029	Castor Seed	173	0.008
28	Arhar	283	0.015	Coriander	130	0.006
29	Gram	275	0.014	Soyabean	117	0.005
30	Potato	96	0.005	Sugarcane	78	0.004
31	Coriander	54	0.003	Potato	32	0.001
32	Lentil	-	-	Isabgol	24	0.001
33	Carom	-	-	Garlic	16	0.001
34	Rice	-	-	Rice	14	0.001
35	Soyabean	-	-	Mehandi	-	-
36	Sugarcane	-	-	Carom	-	-
	Total	1,899,850	100.000	Total	2,153,556	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

Table 11.5 Continued…

ACZ	IIIb			IVa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
1	Mustard	680,175	30.081	Maize	618,286	44.627
2	Bajra	679,069	30.032	Wheat	169,422	12.229
3	Wheat	525,067	23.221	Soyabean	92,901	6.705
4	Jowar	107,008	4.732	Jowar	67,453	4.869
5	Sesamum	70,386	3.113	Mustard	63,361	4.573
6	Gram	55,189	2.441	Urad	53,326	3.849
7	Guar	38,069	1.684	Sesamum	46,832	3.380
8	Barley	21,516	0.952	Cotton	41,132	2.969
9	Taramira	12,898	0.570	Guar	38,248	2.761
10	Medicine and Aeromats	12,330	0.545	Groundnut	33,936	2.449

ACZ	IIIb			IVa		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
11	Maize	8,548	0.378	Gram	23,704	1.711
12	Groundnut	7,690	0.340	Moong	21,785	1.572
13	Onion	7,583	0.335	Barley	17,822	1.286
14	Potato	7,556	0.334	Vegetables	15,621	1.128
15	Vegetables	5,696	0.252	Carom	14,184	1.024
16	Cotton	4,645	0.205	Bajra	12,131	0.876
17	Arhar	3,971	0.176	Castor Seed	11,333	0.818
18	Rice	3,875	0.171	Lentil	6,347	0.458
19	Chillies	2,367	0.105	Rice	5,711	0.412
20	Lentil	2,188	0.097	Garlic	5,220	0.377
21	Fruits	1,750	0.077	Fenugreek	5,155	0.372
22	Urad	1,203	0.053	Arhar	4,009	0.289
23	Fenugreek	836	0.037	Isabgol	2,380	0.172
24	Fennel	411	0.018	Taramira	2,263	0.163
25	Soyabean	356	0.016	Coriander	2,210	0.160
26	Moong	254	0.011	Chillies	2,052	0.148
27	Moth	204	0.009	Cumin	1,919	0.139
28	Sugarcane	171	0.008	Sugarcane	1,709	0.123
29	Coriander	116	0.005	Fruits	1,629	0.118
30	Cowpea	41	0.002	Fennel	1,307	0.094
31	Garlic	-	-	Cowpea	811	0.059
32	Cumin	-	-	Medicine and Aeromats	665	0.048
33	Castor Seed	-	-	Onion	417	0.030
34	Isabgol	-	-	Potato	86	0.006
35	Mehandi	-	-	Moth	72	0.005
36	Carom	-	-	Mehandi	7	0.001
	Total	2,261,168	100.000	Total	1,385,446	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

Table 11.5 Continued…

ACZ	IVb			V		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
1	Maize	279,588	42.585	Soyabean	616,221	27.736
2	Wheat	144,103	21.949	Wheat	405,226	18.239
3	Soyabean	68,785	10.477	Mustard	385,809	17.365
4	Rice	43,411	6.612	Coriander	229,279	10.320
5	Gram	38,808	5.911	Maize	99,251	4.467
6	Urad	25,967	3.955	Medicine and Aeromats	95,920	4.317
7	Cotton	12,651	1.927	Sesamum	82,309	3.705
8	Arhar	8,860	1.350	Gram	77,942	3.508
9	Guar	4,982	0.759	Rice	64,242	2.892
10	Medicine and Aeromats	4,540	0.692	Bajra	50,990	2.295
11	Mustard	4,485	0.683	Urad	19,885	0.895
12	Barley	3,580	0.545	Lentil	16,217	0.730
13	Sesamum	2,667	0.406	Jowar	14,645	0.659

ACZ	IVb			V		
S. No.	Crop	Area, hectare	Percentage	Crop	Area, hectare	Percentage
14	Fenugreek	2,576	0.392	Garlic	13,763	0.619
15	Jowar	2,197	0.335	Taramira	12,413	0.559
16	Lentil	1,571	0.239	Fenugreek	10,778	0.485
17	Garlic	1,378	0.210	Vegetables	9,653	0.434
18	Vegetables	1,165	0.177	Groundnut	5,922	0.267
19	Carom	1,048	0.160	Barley	2,469	0.111
20	Groundnut	1,043	0.159	Chillies	2,248	0.101
21	Chillies	776	0.118	Fruits	1,489	0.067
22	Isabgol	644	0.098	Sugarcane	1,408	0.063
23	Bajra	390	0.059	Guar	713	0.032
24	Sugarcane	264	0.040	Arhar	575	0.026
25	Taramira	245	0.037	Moong	567	0.026
26	Onion	199	0.030	Onion	560	0.025
27	Fruits	169	0.026	Potato	383	0.017
28	Moong	117	0.018	Carom	246	0.011
29	Cowpea	114	0.017	Fennel	220	0.010
30	Castor Seed	82	0.012	Isabgol	187	0.008
31	Cumin	47	0.007	Cowpea	65	0.003
32	Fennel	40	0.006	Cotton	63	0.003
33	Coriander	23	0.004	Moth	49	0.002
34	Potato	22	0.003	Cumin	35	0.002
35	Moth	-	-	Castor Seed	-	-
36	Mehandi	-	-	Mehandi	-	-
	Total	656,537	100.000	Total	2,221,742	100.000

Source: Rajasthan Krishi, Departments of Agriculture and Horticulture, 2010-11 & 2009-10

11.4 Conclusions and Recommendations

Rajasthan’s agriculture sector has an impressive long-term record of taking the state out of serious food shortages despite rapid population increase. This was achieved through a favourable interplay of infrastructure, technology, extension, and policy support. The main source of long-run growth was technology-induced augmentation of yields per unit of cropped area. This resulted in significant gradual increase in yields of cereals, pulses, oilseeds and cluster beans as a promising commercial crop.

The share of different crops in the sown area is a result of agro-climatic conditions, produce consumption and market needs. Thus, bajra occupies the highest percentage in area terms, followed by wheat, cluster bean, mustard and gram.

Geographic expansion enhanced crop production, but the production trend was not uniform. This is because of the rainfall pattern, which plays a major role in the production of rainfed crops. Rainfed crops response well to evenly distributed rains, but uneven and scanty rainfall adversely affects the production.

Among the crops considered for the present study, most show increasing or sustained trends in area, production and productivity, whereas barley, rice, sesamum and urad show a decreasing hectarage along with increase in production and productivity. Gram and jowar decreased in hectarage and production along with increase in productivity. The decrease in hectarage is due to crop preferences by the farmers. A decrease in hectarage of one crop is balanced by the expansion of other, preferred, crops.

Regions suitable for olive cultivation are mostly found around the Mediterranean Sea. Rajasthan is among the few other locations that can be suitable for olive cultivation. Olives have a huge economic potential and an international market. In order to exploit the unharnessed opportunity and to provide the farmers a remunerative crop, the Government of Rajasthan initiated a pilot project to test the technical feasibility and economic viability of growing olives in different agro-climatic zones in the State.

Based upon available data, growth trend lines in field crops were traced by the Consultants and projections for the coming 50 years were obtained by linear extrapolation. The projected crop yields are shown to be achievable by comparing them with yield productivities attained in year 2010 in trials conducted in various Adaptive Trial Centres (ATC).

Even higher yields than presently projected can be achieved by adopting an improved package of crop production practices, suitable high-yielding varieties and appropriate soil and moisture conservation practices.

A strategy to accelerate agricultural growth to desirable levels requires action in the following broad areas.

- Agricultural extension is critical for narrowing the general knowledge gaps existing in agriculture. Appropriate field-level service providers in extension should be trained to impart better agricultural extension services, including a comprehensive and participatory district-planning process. Alternate delivery channels spanning Rural Knowledge Centres and farmer-to-farmer extension should also be promoted simultaneously and the scope of Strategic Research Extension Plans should be enlarged.
- There is also a need to ensure adequate and timely supply of quality inputs; the supply of seeds needs attention on priority. The seed production and distribution system must be revamped by strengthening seed agencies in seed multiplication and distribution system, simultaneously strengthening systems to check quality of inputs; there is evidence that sales of spurious seed, fertilizer, and farm chemicals are on the rise.
- Horticultural development continues to be sluggish. Diversification towards horticulture and livestock will have to be a major element in achieving the desired agricultural growth. Such diversification offers an opportunity for significantly raising farm incomes. Employment elasticity for these activities is quite high, which is also likely to reduce the pressure on natural resources. However, this still largely excludes vegetable production and there is still a shortage of quality planting material.
- Agricultural marketing is a critical element in the diversification strategy. Since high-value agriculture is based on perishable commodities, large investments are required in modern methods of processing, grading, storage and transportation of produce. Such investment would in turn require new players who are able to enter existing markets and set up new marketing channels.
- Economic empowerment of farmers through accelerated yet sustainable growth in agriculture and agrarian economy should be strengthened by tapping the vast agricultural resources of the State through an inclusive development.

- Existing yield gaps should be bridged through adoption and up-scaling of improved technologies, involving community approaches for extension delivery and timely input availability.
- Improved irrigation methods should be promoted and farmers facilitated to adopt them.
- Farmers should be encouraged to prefer growing low-water-requiring and high-remunerating crops.
- Irrigation management practices should be promoted, to increase productivity per unit of water.
- Soil health awareness must be promoted through a credible system of soil testing and of advice on nutrient needs based on soil tests.
- Given that most farmers are small and marginal, and, increasingly female, special steps are needed to improve their effective access to inputs, credit, extension services, and output markets. It is now well recognized that the poor are best empowered if they function as a group rather than as individuals and that this is also the best way to secure economies of scale. Hence for the poor and for women to gain and be effective farmers a group-oriented approach should be encouraged; it can benefit small farmers on many different fronts.
- To cope with long-term climate change due to global warming, it is necessary to focus on adaptive research to make it location-specific and aimed at identifying regionally-relevant best practice according to the following action points.
    - Priority in agriculture research should be given to strategic research.
    - Research priorities have to shift towards evolving cropping systems suited to various agro-climatic conditions and towards enhancing the yield potential of rainfed areas through development of drought- and pest-resistant varieties.
    - More emphasis must be placed on Participatory Irrigation Management, including collection and retention of water rates by water user associations, to reduce the gap between potential created and the actual utilized.
    - Comprehensive water balance accounts must be maintained of current use, both at the system level and at the level of water user associations, to highlight the extent of avoidable waste and identify possibilities of reducing it through better regulation of water deliveries and conjunctive surface and ground water use. Water conservation as underground water than surface water to reduce the evaporation losses.
    - The subsidy structure on micro-irrigation equipment must be restructured to enable promotion of community sprinkler systems by water user associations.
    - Integration of resources to supplement Command Area Development.

12. Inspection of Hydro-Meteorological Stations

Rainfall stations at different Tehsil Head Quarters and WRD Dam sites were inspected by the Consultants, and the findings are as follows.

- At several Tehsil Head Quarters, old instruments are under operation for collecting rainfall and their measuring cylinder is not properly matched with the collecting instrument. At a few places instrument is old and their measuring cylinder under use is of new instrument, hence rainfall being measured is not correct. It is therefore recommended that Rainfall collecting instruments and their measuring cylinders must match each other to get correct rainfall.
- At a few Tehsil Head Quarters, Rainfall collecting instrument is fixed on Roof-top of office building but no proper arrangement of stairs / iron or wooden ladders is available during inspection. Proper approach be kept ready during monsoon period to facilitate the measuring persons and safe guard of glass measuring cylinders.
- It was also observed that the rainfall collecting area of old instruments are less than 200 cm^2 at many raingauge stations of Tehsils. Such old raingauges be replaced by new ones having rain collecting area of 200 cm^2. For which glass measuring cylinders are easily available and can be replaced as per requirement.
- Besides, specific comments about the inspection of hydro-meteorological stations are given in Appendix 15 (Volume 2 of this report).

13. Status of Meteorologic and Hydrologic Measurement Stations in Rajasthan

13.1 Climatological Measurement Equipment

Meteorological measurement equipment has been installed in Rajasthan mainly by:

- India Meteorology Department
- Revenue Department of Rajasthan
- Water Resources Department of Rajasthan

The status of the various types of equipment installed in the State is reviewed in the following paragraphs.

13.1.1 Installed by India Meteorological Department (IMD)

The IMD has installed the following meteorological instruments at various places in Rajasthan.

- self-recording rain gauges
- non recording rain gauges
- thermometers
- wind vanes
- sunshine duration recorders
- solar radiation recorders
- humidity sensors

All these instruments are maintained by IMD and the readings are taken manually by their trained staff.

13.1.2 Installed by the Revenue Department of Rajasthan

Only non-recording raingauges are installed by Rajasthan Revenue Department. They are mostly installed at Tehsil offices or in Panchayat Samiti offices and are maintained and supervised by the revenue staff who also record the observations.

13.1.3 Installed by Rajasthan Water Resources Department

Rajasthan Water Resources Department (RWRD) has installed the following equipment at various locations in the State:

- non recording, manual, raingauges
- self-recording raingauges
- water level recorders
- humidity recorders
- temperature recorders
- all weather stations

13.2 River Gauging Equipment

River gauging, i.e. measuring the water discharge passing a selected fixed point in the river versus time, is done in various rivers in Rajasthan by two agencies:

- Central Water Commission, and
- State Water Resources Department.

13.3 Rain Gauging

13.3.1 Scope

There are 542 rain gauges installed at different locations in Rajasthan, out of which 16 belong to IMD, 209 - to RWRD and rest to the Revenue Department.

All these rain gauge stations are non recording (manual).

Besides, RWRD have installed self-recording rain gauges at 57 locations in the State, of which 17 are in Jaipur Irrigations Zone, 19 in Udaipur Irrigation Zone, 8 Kota Irrigation Zone, 7 in Jodhpur Irrigation Zone and 6 the North Irrigation Zone.

13.3.2 Status of Raingauges

1. Self-Recording Gauges

The self recording rain gauges installed in the state are in working condition but at a few places where these are installed within Automatic Weather Station (AWS) in remote areas the following problems exist:

- batteries out of order (life of battery completed),
- the data logger cards are not working,
- inserted logger cards are missing, and
- the protection fencing is damaged or stolen.

2. Non-Recording Raingauges (Manual)

All such raingauges are functional but in 90% of cases, or more, the following problems are observed.

1) The rain gauges are installed on roofs of buildings. If rain gauges are installed more than 1.5 m above ground level some correction factor should be applied after due analysis. But none of the departments has worked out the correction factor.
2) There are high buildings or trees near the raingauge. According to the norms, the distance of a raingauge from a nearby tree or building should twice the height of the building or tree. In case such a high building or tree has been built or grown-up after the installation of the raingauge, the raingauge should be shifted to a suitable location, as per the norms.
3) In many places the measuring cylinders and the rain collecting bottles are not as per the norms. In the absence of proper measuring cylinders, rain is measured either with broken cylinders or estimated by the observer.
4) The rainfall is not measured at the fixed time every day.
5) In case of heavy rainfall, the measuring of rains is not done hourly.
6) There is no trained staff at many places.

13.4 River Water Level Recorders (WLR)

13.4.1 Introduction

72 electronic float-type water level recorders were installed at various rivers and dam reservoirs in the State so as to cover all river basins and The Outside Basin area. These were installed in 1999 by the Australian Company MinData. The purpose of these instruments was to measure the depth of water flowing at a fixed location and cross section, and by measuring the velocity by current meters, to compute the volume flowing in the rivers. Similarly, the water level recorders fixed on dams were also meant to estimate the volume of water stored in the reservoirs as a function of the depth of water.

13.4.2 Location

The following table shows the location of WLRs per river basin.

Table 13.1 Location of WLRs per River Basin

River Basin		Location of WLR	
1.	Banganga River Basin	1.	Banganga River at Hingota
		2.	Ramgarh Dam – Banganga River
		3.	Sawan River – near Bandikui (Tributary of Banganga River)
2.	Sabi River Basin	1.	Sodawas – Sabi River
		2.	Buchara – Sabi River
3.	Shekhawati River Basin	1.	Kantli river at Bagar (P.T.)
		2.	Medha river at Renwal
4.	Ruparail river Basin	1.	Jaisamand dam – Ruparail – a tributary of Banganga
		2.	U/s of Sikri dam – Ruparail river
5.	Banas river Basin	1.	Dal river at Sarwar
		2.	Mashi river at Chhaparwara
		3.	Mashi Dam – Mashi River
		4.	Tordi Sagar – Sohdara river

River Basin		Location of WLR	
		5.	Mashi river at Hingonia
		6.	Dund river at Kanota
		7.	Morel Dam (Morel River)
		8.	Kareli River near Kunkota
		9.	Dheel Dam (Dheel River)
		10.	Lassaria reservoir
		11.	Kari river at Bandawa
		12.	Bisalpur dam
		13.	Gambhiri river at Ochari
		14.	Berach River at Badgaon
		15.	Gosunda Dam – Berach river
		16.	Arwar reservoir
		17.	Narayan sagar reservoir
		18.	Meja Reservoir
		19.	Kothari reservoir
		20.	Banas river at Bigod
		21.	Banas river at Matrikundia
		22.	Rajsamand dam – Banas river
6.	Gambhir River Basin	1.	Baretha dam (Gambhir river)
		2.	Gambhir river at Sri Mahavirji
7.	Parbati River Basin	1.	Parbati River near Kumheri
8.	Chambal River Basin	1.	R.P.S. Dam – Chambal River
		2.	J.S. Dam – Chambal River
		3.	Gudha Dam – Mej river
		4.	Mej River – NH12 Road
		5.	Parwati River at Gujor
		6.	Parwan river near Manohar Thana
		7.	Kali Sindh Pick up weir
		8.	Ahu river at Suket
		9.	Ahu river near Arwar
9.	Sabarmati River Basin	1.	Wakal river near Dangria
10.	Mahi River Basin	1.	Mahi Dam – Mahi River
		2.	Som Kamla Amba dam – Som river
		3.	Jai Samand Dam – Som River
		4.	Somkagdar Dam – Som River
		5.	Jakham river at Nagalia Pick up weir
		6.	Jakham Dam – Jakham river
11.	West Banas river Basin	1.	West Banas dam – West Banas River
12.	Sukli River Basin	1.	Sipu river near Karaunti
13.	Luni River Basin	1.	Bandi river at Raniwara
		2.	Bandi river at Gadi
		3.	Jojari river at Pipar (Jaliwara)
		4.	Jaswant Sagar Dam
		5.	Luni River at Samadri
		6.	Luni River near village Alniawas
		7.	Luni River at Kankani
		8.	Sukri River at Sojat

River Basin		Location of WLR	
		9.	Guhija river at Singari
		10.	Bandi river near Pali
		11.	Hemawas dam on Bandi river
		12.	Bandi river at Gundoj
		13.	Bankli dam
		14.	Mithri river at Sanderao
		15.	Jawai dam on Jawai river
14.	Other Nallahs of Jalore District	1.	Jawai river at Jalore
		2.	Sardar Samand dam- Guhija river
15.	Outside Basin	1.	Ghaggar Canal

13.4.3 Status

The company MinData undertook to maintain these instruments for three years after installation and thereafter to provide all the software and transfer of technology. But they did not do so, which resulted in absence of maintenance and repair of this equipment, due to the absence of software and technology. These instruments worked partly and some of them did not work at all. The RWRD could not do the necessary repairs and maintenance due to lack of required budget. Some of these WLRs have been working up to year 2005-06, but now none of them is operational.

The main difficulties with the WLRs are:

- the department does not have the necessary software and the technology of these instruments,
- batteries of all the equipments un-usable,
- inserted logger cards are missing
- internal cards are damaged,
- rollers or floating drums have become ineffective, resulting in incorrect presentation of graphs,
- WLRs in many places are damaged,
- wiring and connecting cables are damaged,
- internal and underground cables are damaged,
- the internal mechanism of WLRs does not work,
- the protecting fencing has been damaged or stolen,
- most of the equipment is unguarded, and
- the Department does not have enough current meters in working condition.

13.5 Automatic Weather Stations (AWS)

13.5.1 General

Automatic Weather Stations (AWSs) were established in Rajasthan by the IMD and by RWRD.

The following weather parameters are observed in AWSs:

- wind speed

- wind direction
- temperature
- humidity
- solar radiations and sun shine data

13.5.2 AWS and Observatories Established by the IMD

IMD has installed AWSs at 36 locations in Rajasthan (listed below) measuring rainfall (by SRRGs) Atmospheric pressure, temperature, wind speed and wind direction. Besides these one SRRG has been installed at Banswara by CWC.

30 observatories were established by the IMD in Rajasthan with traditional equipment. All are functioning and are maintained and observed manually by the trained staff of IMD. The location of these observatories is as below.

Table 13.2 Automatic Weather Stations (AWS) Maintained by IMD in Rajasthan

S. No.	District	Station	Type	Station ID	Latitude	Longitude	Altitude, m
1	Ajmer	Ajmer	AWS	A0A78A16	26°26'60"	74°37'12"	285
2	Alwar	Alwar	AWS	A0A797B2	27°30'00"	76°34'48"	271
3	Banswara	Banswara	AWS	A0A79960	23°33'00"	74°27'00"	220
4	Banswara	Banswara	AGRO-AWS	A0A7A228	23°33'00"	74°27'00"	220
5	Baran	Baran	AWS	A0A7ACFA	25°07'12"	76°31'12"	262
6	Barmer	Barmer	AWS	A0A7B15E	25°45'00"	71°22'48"	194
7	Bharatpur	Bharatpur	AGRO-AWS	A0A7BF8C	27°21'00"	77°49'48"	181
8	Bhilwara	Bhilwara	AWS	A0A7C7CE	25°23'60"	74°10'12"	421
9	Bikaner	Bikaner	AGRO-AWS	A0A7C91C	28°01'12"	73°16'12"	224
10	Bundi	Bundi	AWS	A0A7D4B8	25°26'60"	75°37'48"	267
11	Chittaurgarh	Chittaurgarh	AWS	A0A7DA6A	24°25'12"	74°28'48"	394
12	Churu	Churu	AWS	A0A7E122	28°15'00"	74°58'12"	291
13	Dausa	Dausa	AWS	A0A7EFF0	27°08'60"	76°34'48"	327
14	Dhaulpur	Dhaulpur	AWS	A0A7F254	26°40'12"	77°49'48"	176
15	Dungarpur	Dungarpur	AWS	A0A7FC86	23°51'00"	73°43'12"	429
16	Sikar	Fatehpur	AGRO-AWS	A0A80442	28°00'00"	75°00'00"	432
17	Ganganagar	Ganganagar	AWS	A0A80A90	29°55'12"	74°19'12"	117
18	Jaipur	Jaipur	AGRO-AWS	A0A81734	26°51'00"	75°46'48"	121
19	Jalore	Jalore	AWS	A0A819E6	25°21'00"	72°37'12"	167
20	Jhalawar	Jhalawar	AWS	A0A822AE	24°31'48"	76°10'12"	321
21	Jodhpur	Jodhpur	AGRO-AWS	A0A82C7C	26°18'00"	73°01'12"	224
22	Karauli	Karauli	AWS	A0A831D8	26°30'00"	77°01'12"	275
23	Kota	Kota	AGRO-AWS	A0A83F0A	25°10'48"	75°04'48"	257

S. No.	District	Station	Type	Station ID	Latitude	Longitude	Altitude, m
24	Kota	Kota	AWS	A0A84748	25°08'60"	75°50'60"	274
25	KOTA	ANTA	AWS	A0B2EFAE	25°10'12"	76°19'12"	250
26	Sirohi	Mount Abu	AWS	A0A8499A	24°36'00"	72°43'12"	1195
27	Nagaur	Nagaur	AWS	A0A8543E	27°10'12"	73°40'12"	298
28	Pali	Pali	AWS	A0A85AEC	25°46'48"	73°19'48"	212
29	Jhunjhunu	Pilani	AWS	A0A861A4	28°19'48"	75°34'48"	301
30	Pratapgarh	Pratapgarh	AWS	A0A86F76	24°03'00"	74°46'48"	489
31	Rajsamand	Rajsamand	AWS	A0A872D2	25°04'12"	73°52'48"	547
32	Sawai Madhopur	Sawai Madhopur	AWS	A0A87C00	25°58'48"	76°22'12"	265
33	Sikar	Sikar	AWS	A0A88256	27°37'12"	75°07'48"	432
34	Sriganga Nagar	Sriganga Nagar	AGRO-AWS	A0A88C84	29°55'12"	73°52'48"	176
35	Tonk	Tonk	AWS	A0A89120	26°10'12"	75°45'00"	272
36	Udaipur	Udaipur	AGRO-AWS	A0A89FF2	24°34'48"	73°42'00"	582

Table 13.3 Observatories Maintained by IMD in Rajasthan

S. No.	Index No.	Station Name	Latitude	Longitude	ACZ	Block	District
1	10205	Kota pbo	25°10'48"	75°04'48"	IVa	Mandalgarh	Bhilwara
2	42123	Ganga nagar	29°55'12"	73°52'48"	Ib	Ganganagar	Ganganagar
3	42165	Bikaner pbo	28°00'00"	73°17'60"	Ic	Bikaner	Bikaner
4	42170	Churu	28°15'00"	74°55'12"	IIa	Churu	Churu
5	42174	Pilani	28°19'48"	75°34'48"	IIa	Chirawa	Jhunjhunun
6	42237	Phalodi	27°07'48"	72°22'12"	Ia	Phalodi	Jodhpur
7	42242	Nagaur	27°10'12"	73°40'12"	IIa	Nagaur	Nagaur
8	42249	Sikar	27°37'12"	75°07'48"	IIa	Piprali	Sikar
9	42258	Bharatpur	27°12'36"	77°30'00"	IIIb	Sewar	Bharatpur
10	42328	Jaisalmer	26°53'60"	70°55'12"	Ic	Jaisalmer	Jaisalmer
11	42339	Jodhpur (a)	26°18'00"	73°00'36"	Ia	Mandor	Jodhpur
12	42343	Ajmer	26°26'60"	74°37'12"	IIIa	Peesangan	Ajmer
13	42348	Jaipur / Sanganer	26°49'12"	75°47'60"	IIIa	Amber	Jaipur
14	42349	Tonk	26°10'12"	75°45'00"	IIIa	Tonk	Tonk
15	42354	Dholpur	26°40'12"	77°49'48"	IIIb	Dhaulpur	Dhaulpur
16	42435	Barmer	25°45'00"	71°22'48"	Ia	Barmer	Barmer
17	42439	Jalore	25°21'00"	72°37'12"	IIb	Jalore	Jalore
18	42441	Jawai bandh	25°04'48"	73°04'48"	IIb	Sheoganj	Sirohi
19	42447	Bhilwara	25°21'00"	74°37'48"	IVa	Suwana	Bhilwara
20	42450	Bundi	25°26'60"	75°37'48"	V	Hindoli	Bundi

S. No.	Index No.	Station Name	Latitude	Longitude	ACZ	Block	District
21	42452	Kota (a)	25°08'60"	75°50'60"	V	Ladpur	Kota
22	42453	Sawai Madhopur	26°00'00"	76°20'60"	V	Sawai Madhopur	Sawai Madhopur
23	42540	Abu (mountabu)	24°36'00"	72°42'36"	IVa	Abu Road	Sirohi
24	42542	Udaipur (dabok)	24°37'12"	73°52'48"	IVa	Mavli	Udaipur
25	42543	Udaipur	24°34'48"	73°42'00"	IVa	Girwa	Udaipur
26	42546	Chittorgarh	24°52'48"	74°37'48"	IVa	Chittorgarh	Chittorgarh
27	42552	Chambal (rawat bhata)	24°55'12"	75°34'48"	IVa	Bhainsrorgarh	Chittorgarh
28	42555	Jhalawar	24°31'48"	76°10'12"	V	Jhalrapatan	Jhalawar
29	42655	Banswara	23°33'00"	74°27'00"	IVb	Banswara	Banswara
30	42346	Jobner	26°58'12"	75°22'48"	IIIa	Sambhar	Jaipur

13.5.3 AWS Installed by the RWRD

1) One observatory was installed by the RWRD in Kanota based on the IMD pattern, and is in operation.
2) 11 AWSs were installed by RWRD 11 at various locations in Rajasthan, covering important river basins. All the equipment is electronic, installed by MinData in 1999.

The following table gives the location of AWSs basin-wise.

Table 13.4 Location of AWSs Basin-wise

River Basin		Location of AWS	
1.	Banganga	1.	Jaipur (RWRD Building)
		2.	Bandikui (Dausa District)
2.	Chambal	1.	Lawan (Bundi District)
		2.	Jhalawar
3.	Luni	1.	Sendra (Pali District)
		2.	Bankli (Jalore District)
4.	Banas	1.	Arwar (Bhilwara District)
		2.	Udaipur
5.	The Outside Basin	1.	Suratgarh Branch Jn. (Sriganganagar District)
		2.	Charanwala (Bikaner District)
		3.	Ramgarh (Jaisalmer District)

13.5.4 Status of AWSs

As explained above in the case of WLRs, since MinData did not maintain, nor transfer the software and technology, the condition of AWS is the same as that of WLRs. The main difficulties are as follows:

- the department does not have the necessary software and the technology of these instruments,
- batteries of all the equipment are un-usable,
- inserted logger cards are missing,

- internal cards are damaged,
- the equipment got damaged at some places,
- wiring and connecting cables are damaged,
- internal and underground cables are damaged,
- internal mechanisms are not working,
- solar panels have been damaged or stolen at some places,
- the protecting fences have been damaged or stolen, and
- most of the equipment is not guarded.

13.6 River Gauging

River gauge and discharge (G&D) measurements in Rajasthan are made by two agencies:

- the Central Water Commission (CWC), and
- Rajasthan Water Resources Department (RWRD).

13.6.1 River Gauge and Discharge (G&D) Sites of CWC

River gauge and discharge measurements are made by the CWC in Chambal, Luni, Banas, Mahi and West Banas river basins. The locations are as follows:

Table 13.5 River G&D Sites of CWC

River Basin	Site	River
Chambal	Palighat	Chambal
	Mandrail	Chambal
	Aklera	Parwan
	Sangod	Parwan
	Barod	Kalisindh
	Salawad	Kalisindh
	Khatoli	Parbati
	Dholpur	Chambal
	Mandawra	Chambal
Banas	Chittorgarh	Gambhiri
	Bigod	Banas
	Tonk	Banas
	Baranwada	Banas
	Nimoda on Morel	Banas
	Pipli	Banas
Mahi	Rangoli (on Som)	Mahi
	Anas at PH-2	Mahi
	Chandangarh / Mataji	Mahi
	Paderdibadi	Mahi
	Kadana	Mahi
Luni	Gandhava/ Chitalvana	Luni
West Banas	Abu Road	West Banas

The CWC sites are all functional, maintained by the CWC, and observations are taken regularly by the trained staff. The five sites closed by CWC in Shekhawati Basin and Luni Basin are not covered in this list.

13.6.2 River G&D sites of RWRD

The RWRD have established two types of river gauging setup.

- operated manually
- equipped with WLR and a cable way

1. River Gauging Sites Operated Manually

There are 25 sites where river gauging is done manually by the RWRD in 6 river basins. These are listed below.

Table 13.6 River Gauging Sites

	Gauge Discharge Site	River	Status
A.	Banas Basin		
1.	Chittorgarh at Berach river	Berach	Only gauge readings are taken on a very old cross section of the river, which has never been re-surveyed. No discharge rating curve is available. Thus, water flow-rate and volume cannot be assessed.
2.	Chittorgarh at Gambhiri river	Gambhiri	Only gauge readings are taken on a very old cross section of the river, which has never been re-surveyed. No discharge rating curve is available. Thus, water flow-rate and volume cannot be assessed.
3.	Wagon	Banas	Observations are made during the Monsoon period, but the river’s cross-section has not been verified since the site installation.
4.	Matrikundia pick up weir	Matrikundia	Observations are made during the Monsoon period, but the river’s cross-section has not been verified since the site installation.
5.	Kothari dam	Kothari	No cross section of the gauging site is available and no previous years’ observation data are available.
6.	Chhaparkeri site in Ajmer District	Gomti	No cross section of the gauging site is available and no previous years’ observation data are available.
7.	Kanota site	Dhund	The last observations were taken in 1998. After 1998, no readings have been taken. The WLR of this site is also not working.
B.	Banganga basin		
1.	Hingota near Chhonkarwada	Banganga	No cross-section of the river is available, nor level/discharge rating curve. Observations have not being made for the last 15 years or more. Earlier gauging data are incomplete and irregular, and of no use.
C.	Gambhir Basin		
1.	Sri Mahavirji	Gambhir	No data are available. No river cross-section at the G&D site is available
2.	Samogarh railway bridge	Gambhir	No G&D data are available. Gauging is not done regularly at a fixed time. Level/discharge curves are also not available.

	Gauge Discharge Site	River	Status
3.	Bayana Railway bridge	Gambhir	No G&D data are available. Gauging is not done regularly at a fixed time. Level/discharge curves are also not available.
D.	Chambal Basin		
1.	R.P.S. Dam	Chambal	Proper gauging is done. Data are available
2.	J.S. Dam	Chambal	Proper gauging is done. Data are available
3.	Kota Barrage	Chambal	Proper gauging is done. Data are available
4.	Manohar thana	Parwan	No data are available. Regular gauging is not being done.
5.	Kalisindh pick up weir	Kalisindh	No data are available. Regular gauging is not being done.
6.	Parwan pick up weir	Parwan	No data are available. Regular gauging is not being done.
E.	Luni River Basin		
1.	Govindgarh	Saraswati	No gauging or any other data are available. Observations have not been made for a long time.
F.	Mahi Basin		Proper gauging is done. Data are available
1.	Mahi Dam	Mahi	
2.	Dhariyawad	Jakham	Proper gauging is done. Data are available
3.	Nagalia pick up weir	Nagalia	Proper gauging is done. Data are available
4.	Karmai pick up weir	Karmai	Proper gauging is done. Data are available
5.	Aspur	Som	Proper gauging is done. Data are available

2. Gauging Sites with WLRs and Cableways

In 1999 the RWRD installed at seven places G&D electronic observation systems with WLRs and cableways, where river levels were measured by WLRs fitted on a cableway and the river discharge was measured using current meters. These systems were set up by the MinData company.

The locations of these sites are as follows.

River Basin	Location
Ruparail	Upstream of Sikri Dam
Banganga	Sanwan river near Bandikui
Chambal	On Mej river at Jhaliji ka Barana village
Chambal	On Parwan river near Manohar Thana
West Banas	Sipu river near Karakunti
Luni	Luni river near village Alniawas
Sabarmati	Wakal river near village Dangaria

3. Status of Cableways at River Gauging Sites

None of the cableways in gauging sites is operative; they have not been working properly since installation. The main problems are as follows:

- RWRD do not have the necessary software and technology of these instruments,
- batteries of all the instruments are un-usable,

- inserted logger cards are missing,
- internal cards are damaged,
- rollers and floating drums have become ineffective, resulting in improper presentation of graphs,
- WLRs are damaged in many places,
- wiring and connecting cables are damaged,
- internal and underground cables are damaged,
- internal mechanism of WLRs is not working,
- protective fences have been damaged or stolen,
- most of the equipment is unguarded, and
- the Department does not have enough current meters in working condition.

14. Density of Hydrologic Stations for a Minimum Network

14.1 Introduction

There are many references which deal with the issue of network measurements density for hydrological purposes. A detailed description of the WMO recommendations (adopted for the state of Rajasthan in the final section of the present document) is given in the following paragraph where a summary of other recommendations are following their footsteps.

14.2 WMO Recommendations

The minimum network is one that will avoid serious deficiencies in developing and managing water resources on a scale commensurate with the overall level of economic development and environmental needs of the country. It should be developed as rapidly as possible, incorporating existing stations, as appropriate. In other words, such a network will provide the framework for expansion to meet the information needs of specific water uses.

The concept of network density is intended to serve as a general guideline, if specific guidance is lacking. As such, the design densities must be adjusted to reflect actual socio-economic and physio-climatic conditions. Computer-based mathematical analysis techniques should also be applied, where data are available, to optimize the network density required to satisfy specific needs. For example, the network analysis using generalized least squares (NAUGLS) developed by the U.S. Geological Survey[9] offers a promising approach for optimizing the stream gauges in a basic network for regional information.

In the following sections, minimum densities of various types of hydrological stations are recommended for different climatic and geographic zones. It is impossible to define a sufficient number of zones to represent the complete variety of hydrological conditions. A limited number of larger zones have been defined in a somewhat arbitrary manner.

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[9] Moss, M. E. and Tasker, G. D., 1991: An intercomparison of hydrological network design technologies. *Hydrological Science Journal,* Vol. 36, No. 3, pp. 209-221.

The simplest and most precise criterion for the classification of zones would be on the basis of the areal and seasonal variation of rainfall. Each country could present a good map of annual precipitation and a minimum network would be developed from this. But this would not help the various countries that need a network most, as they have very few prior records, and the establishment of a good precipitation map is impossible. One must consider, as a special category, the countries with very irregular rainfall distribution. It is not advisable to base the classification on this one characteristic.

Population density also affects network design. It is almost impossible to install and operate, in a satisfactory way, a number of stations where population is sparse.

For example, to set up more than two gauges on a catchment of 1,000 km^2, when the population of the area is only 100 people, is almost impossible, especially if this population is not permanent. Besides, it is difficult even to find observers in thinly-populated areas where access is poor. Sparsely-settled zones, in general, coincide with various climatic extremes, such as arid regions, polar regions, or tropical forests.

The use of totalizers (storage gauges) is recommended in such cases because they need little maintenance and infrequent visits.

On the other extreme, densely-populated urban areas need a very dense rain gauge network for both temporal and spatial resolution of storms and for design, management, and real-time control of the storm-drainage systems and for other engineering applications.

From these considerations, some general rules have been adopted for the definition of density norms. Six types of physiographic regions have been defined for minimum networks:

- Coastal,
- Mountainous,
- Interior plains,
- Hilly/undulating,
- Small islands (surface areas less than 500 km^2), and
- Polar/arid.

For the last type of region, it is necessary to group together the areas in which it does not seem currently possible to achieve completely acceptable densities because of sparse population, poor development of communication facilities, or for other economic reasons.

14.3 Minimum Densities for Climatological Stations

The following kinds of data are collected at a climatological station in the basic network: precipitation, snow survey and evaporation. It is understood here that evaporation or snow-measuring stations, particularly the former, will generally measure temperature, humidity, and wind because these meteorological elements affect evaporation and melting.

14.3.1 Precipitation stations

The minimum densities for precipitation stations are presented in Table 14.1. These densities are not applicable to the great deserts (Sahara, Gobi, Arabian, etc.) and great ice fields (Antarctic, Greenland, and the Arctic islands) that have no organized hydrographic networks. In these regions, precipitation is not studied by rain gauge networks of standard type, but by special stations and methods of observation.

If one follows certain principles of installation and use, the small number of stations in the minimum network can furnish the most immediate needs. In general, precipitation gauges should be as uniformly distributed as is consistent with practical needs for data and the location of volunteer observers. In mountainous regions, attention must be given to vertical zonality by using storage gauges to measure precipitation at high altitudes. Snow surveys may be used to supplement the network, but they should not be counted as part of the network.

The minimum network should consist of three kinds of gauges:

(a) Standard gauges

These gauges are read daily for quantity. Besides daily depth of precipitation, observations of snowfall, the depth of snow on the ground, and the state of the weather are to be made at each standard precipitation station;

(b) Recorders

In developing networks, it is advisable to aim to have at least 10 per cent of such stations in cold climates. The greatest density of recording stations should be achieved in those areas subject to intense, short-duration rainfalls.

Such stations will provide valuable information on the intensity, distribution, and duration of precipitation. For urban areas where the time resolution needed for rainfall measurements is of the order of one to two minutes, special attention should be paid to the time synchronization of the rain gauges. For reliable measurements, tipping-bucket rain gauges with an electronic memory (or another computer readable medium) are recommended.

In assigning priorities to locations for recording rain gauge installations, the following types of areas should be given priority: urban areas (population in excess of 10,000) where extensive drainage systems are likely to be constructed, river basins in which major river control systems are anticipated or in operation, large areas inadequately covered by the existing network, and special research projects.

(c) Storage Gauges (totalizers)

In sparsely settled or remote regions, such as in desert or mountainous terrain, storage gauges may be used. These gauges are read monthly, seasonally, or whenever it is possible to inspect the stations.

Table 14.1 Recommended Minimum Densities of Precipitation Stations

Physiographic Unit	Minimum densities per station (area in km^2 per station)	
	Non -recording	Recording
Coastal	900	9,000
Mountainous	250	2,500
Interior plains	575	5,750
Hilly/undulating	575	5,750
Small islands	25	250
Urban areas		10-20
Polar/arid	10,000	100,000

14.3.2 Evaporation Stations

Evaporation can be estimated indirectly in the water-budget, energy-budget and aerodynamic approaches, and directly by extrapolation from pan measurements. An evaporation station consists of a pan of standard national designs where daily observations of evaporation are made, together with daily observations of precipitation, maximum and minimum water and air temperatures, wind movement, and relative humidity or dew point temperature. The norms recommended for a minimum network of evaporation stations within areas of uniform physiography are given in Table.14.2.

Evaporation plays an important role for long-term studies of the water regime of lakes and reservoirs and for water management. In such cases, the number and distribution of evaporation stations are determined according to the area and configuration of the lakes and the climatic region or regions involved.

Table 14.2 Recommended Minimum Densities of Evaporation Stations

Physiographic Unit	Minimum densities per station (area in km^2 per station)
Coastal	50,000
Mountainous	50,000
Interior plains	50,000
Hilly/undulating	50,000
Small islands	50,000
Polar/arid	100,000

14.4 Minimum Densities for Hydrometric Stations

14.4.1 Streamflow Stations

The main objective of the stream-gauging network is to obtain information on the availability of surface-water resources, their geographical distribution and their variability in time. Magnitude and frequency of floods and droughts are of particular importance in this regard.

The minimum densities for stream flow stations are given in Table.14.3.

Table 14.3 Recommended Minimum Densities of Stream Flow Stations

Physiographic Unit	Minimum densities per station (area in Km^2 per station)
Coastal	2,750
Mountainous	1,000
Interior plains	1,875
Hilly/undulating	1,875
Small islands	300
Polar/arid	20,000

These norms are not applicable to the great deserts with no defined stream networks (such as the Sahara, Gobi, Arabian and Karakorum deserts) and great ice fields (Antarctic, Greenland, Arctic Islands).

In general, a sufficient number of streamflow stations should be located along the main stems of large streams to permit interpolation of discharge between the stations. The specific location of these stations should be governed by topographic and climatic considerations. If the difference in flow between two points on the same river is not greater than the limit of error of measurement at the station, then an additional station is unjustified. In this context, it must also be stressed that the discharge of a small tributary cannot be determined accurately by subtracting the flows at two mainstream gauging stations which bracket the mouth of the tributary. Where the tributary flow is of special interest in such a case, a station on the tributary will be required. It will usually take its place as a secondary station in the minimum network. The streamflow stations may be interspersed with stage stations mentioned below.

Wherever possible, the base stations should be located on streams with natural regimes. Where this is impractical, it may be necessary to establish additional stations on canals or reservoirs to obtain the necessary data to reconstruct the natural flows at the base stations. Computed flows past hydroelectric plants or control dams may be useful for this purpose, but provisions will have to be made for calibration of the control structures and turbines and for the periodic checking of such calibrations during the life of the plants.

Stations should be located on the lower reaches of the major rivers of the country, immediately above the river mouths (usually above tidal influence), or where the rivers cross borders. Stations should also be located where rivers issue from mountains and above the points of withdrawal for irrigation water. Other hydrometric stations are situated at points such as where the discharge varies to a considerable extent, below the points of entry of the major tributaries, at the outlets from lakes, and at those locations where large structures are likely to be built.

To ensure adequate sampling, there should be at least as many gauging stations on small streams as on the main streams. However, for small streams, a sampling procedure becomes necessary as it is impracticable to establish gauging stations on all of them. The discharge of small rivers is strongly influenced by local factors. In highly developed regions, where even the smallest watercourses are economically important, network deficiencies are keenly felt even on streams draining areas as small as 10 km^2.

Stations should be installed to gauge the runoff in different geologic and topographic environments. Because runoff varies greatly with elevation in mountains, the basic network stations must be located in such a way that they can, more or less evenly, serve all parts of a mountainous area, from the foothills to the higher regions.

Account should be taken of the varying exposure of slopes, which is of great significance in rough terrain. Similarly, consideration should be given to stations in districts containing numerous lakes, whose influence can be determined only through the installation of additional stations.

14.4.2 River Stages

Stage (height of water surface) is observed at all stream-gauging stations to determine discharge. There are places where additional observations of water level only are needed as part of a minimum network:

(*a*) At all major cities along rivers, river stages are used for flood forecasting, water supply, and transportation purposes; and

(*b*) On major rivers, at points between stream-gauging stations, records of river stage may be used for flood routing and forecasting purposes.

14.4.3 Lake and Reservoir Stages

Stage, temperature, surge, salinity, ice formation, etc., should be observed at lake and reservoir stations. Stations should be established on lakes and reservoirs with surface areas greater than 100 km^2. As in the case of rivers, the network should sample some smaller lakes and reservoirs as well.

14.5 Sediment Discharge and Sedimentation

Sediment stations may be designed either to measure total sediment discharge to the ocean or to measure the erosion, transport and deposition of sediments within a country, basin, etc. In designing a minimum network, emphasis should be placed on erosion, transport, and deposition of sediment within a country. An optimum network would contain a sediment station at the mouth of each important river discharging into the sea.

Sediment transport by rivers is a major problem in arid regions, particularly in those regions underlain by friable soils and in mountainous regions where, for engineering applications, the amount of sediment loads should be known.

Although the densities given in Table 14.4 serve as guides in considering a basic network, the designer must be forewarned that sediment transport data are much more expensive to collect than other hydrological records. Consequently, great care must be exercised in selecting the number and location of sediment-transport stations.

Emphasis should be placed on those areas where erosion is known to be severe. After a few years of experience, it may be desirable to discontinue sediment measurements at those stations where sediment transport no longer appears to be of importance.

Sediment-transport data may be supplemented by surveys of sediment trapped in lakes or reservoirs. Echo sounding devices are useful for this purpose. However, information obtained in this way is not considered a substitute for sediment-transport measurements at river stations.

Table 14.4 Recommended Minimum Densities of Sediment Stations

Physiographic Unit	Minimum Densities per Station (area in km^2 per station)
Coastal	18,300
Mountainous	6,700
Interior plains	12,500
Hilly/undulating	12,500
Small islands	2,000
Polar/arid	200,000

14.6 Recommendations in Other References

In various parts of the world the recommendations referred to the rainfall and hydrometric stations network density were different from the above-mentioned WMO recommendations, as described by Table 14.5.

Table 14.5 Network Densities in Other Parts of the World

Country	Density (area in km^2 per station)	Comments	Clarifications
Israel	20	RS*, Personal knowledge	* Rainfall stations
Cyprus[10]	49	RS*	
Cyprus	194	HS**	** Hydrometric stations
Bolivia[11]	82	RS*	
Indonesia[12]	100	RS*	
South Africa[13]	111	RS*	
USA[14]	170	RS* (with 10% error of estimate of areal rainfall)	

General recommendations referred to network density selection are presented by HP Technical Assistance (2003)[15].

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[10] Rossel, F.,2001, Hydrological network analysis and optimization, TCP/CYP/8921

[11] Villazon, M.F., Willems, P., 2010, Filling gaps and daily dis-accumulation of precipitation data for rainfall-runoff model, BALWOIS 2010 – Ohrid, Republic of Macedonia

[12] Prasetijo, H., Montarcih, L., Prasetyorini, L., 2011, Analysis of average rainfall using Kagan Rodda, J. of Applies Sciences Research, 7 (3):309-313.

[13] Scheffler, C., Krause, P, Flugel, W.A., Bongarz, K., 2008, Development of validation tool for regional distribution models using coarse scale soil moisture products, case study: Great Letaba River, South Africa., Friedrich-Schiller University Jena.

[14] U. S. Army Corps of Engineers, 1994, Chapter 4: Rainfall Analysis, in Flood-Runoff Analysis, Engineer Manual 1110-2-1417.

[15] Hydrology Project Technical assistance, 2003, Volume 3: Hydro-Meteorology. Field Manual – Part 1, Network Design and Site Selection. Government of India & Government of the Netherland.

15. International Norms for Installation of Hydro-Meteorological Instruments

15.1 Siting and Exposure

Selecting an appropriate site for the weather station is critical for obtaining accurate meteorological data. Typically, the site should represent the general area of interest, and be away from obstructions such as buildings and trees.

Guidelines condensed from the following publications:

- The State Climatologist (1985). Publication of the American Association of State Climatologists (AASC): Heights and Exposure
- Standards for Sensor on Automated Weather Stations, v. 9, No. 4, October, 1985.
- EPA (1987). On-Site Meteorological Program Guidance for Regulatory Modelling Applications, EPA-450/4-87-013. Office of Air Quality Planning and Standards, Research Triangle Parks, North Carolina 27711.
- WMO (1983). Guide to Meteorological Instruments and Methods of Observation. World Meteorological Organization (WMO) No. 8, 5th edition, Geneva Switzerland.

15.2 Wind Speed and Direction

Wind sensors should be located over open level terrain. The Environmental Protection Agency, United States of America (EPA) recommends the wind sensor be a distance of at least ten times the height of nearby buildings, trees, or other obstructions.

Standard measurement heights:

- 3.0 m ± 0.1 m recommended (AASC)
- 2.0 m ± 0.1 m, 10.0 m ± 0.5 m optional (AASC)
- 10.0 m (WMO and EPA)

15.3 Temperature and Relative Humidity

The sensor should be housed in a ventilated radiation shield. The EPA recommends the sensor be no closer than four times an obstruction’s height, at least 30 m from large paved areas, and located in an open level area that’s at least 9 m in diameter. The open areas should be covered by short grass, or where grass does not grow, the natural earth.

Avoid these:

⇒ large industrial heat sources
⇒ rooftops
⇒ steep slopes
⇒ sheltered hollows
⇒ high vegetation
⇒ shaded areas
⇒ swamps
⇒ areas where snow drifts occur
⇒ low places holding standing water after rains

Standard measurement heights:

- 1.5 m ± 1.0 m (AASC)
- 1.25 to 2.0 m (WMO)
- 2.0 m temperature (EPA)
- 2.0 m and 10.0 m for temperature difference (EPA)

15.4 Precipitation

The AASC and EPA suggest tipping buckets be no closer than four times the height of an obstruction. The orifice of the gage must be in a horizontal plane, open to the sky, and above the level of in-splashing and snow accumulation. Typically, tipping buckets are sited on level ground covered with short grass or gravel. Wind shields, such as those used by the National Weather Service, are recommended for open areas.

Standard measurement heights:

- m ± 1.0 cm (AASC)
- 30.0 cm minimum (WMO, EPA)

15.5 Solar Radiation

Pyranometers should be mounted away from shadows, reflective surfaces, and sources of artificial radiation. Mounting the pyranometer on the southernmost (northern hemisphere) part (either cross-arm or pyranometer mounting arm) of the weather station should minimize shading from the other weather station structures. The height the sensor is mounted is not critical for the accuracy of the measurement. However, pyranometers mounted at heights of 3 m or less are easier to level and clean.

16. Recommendations for Hydro-Meteorological Stations

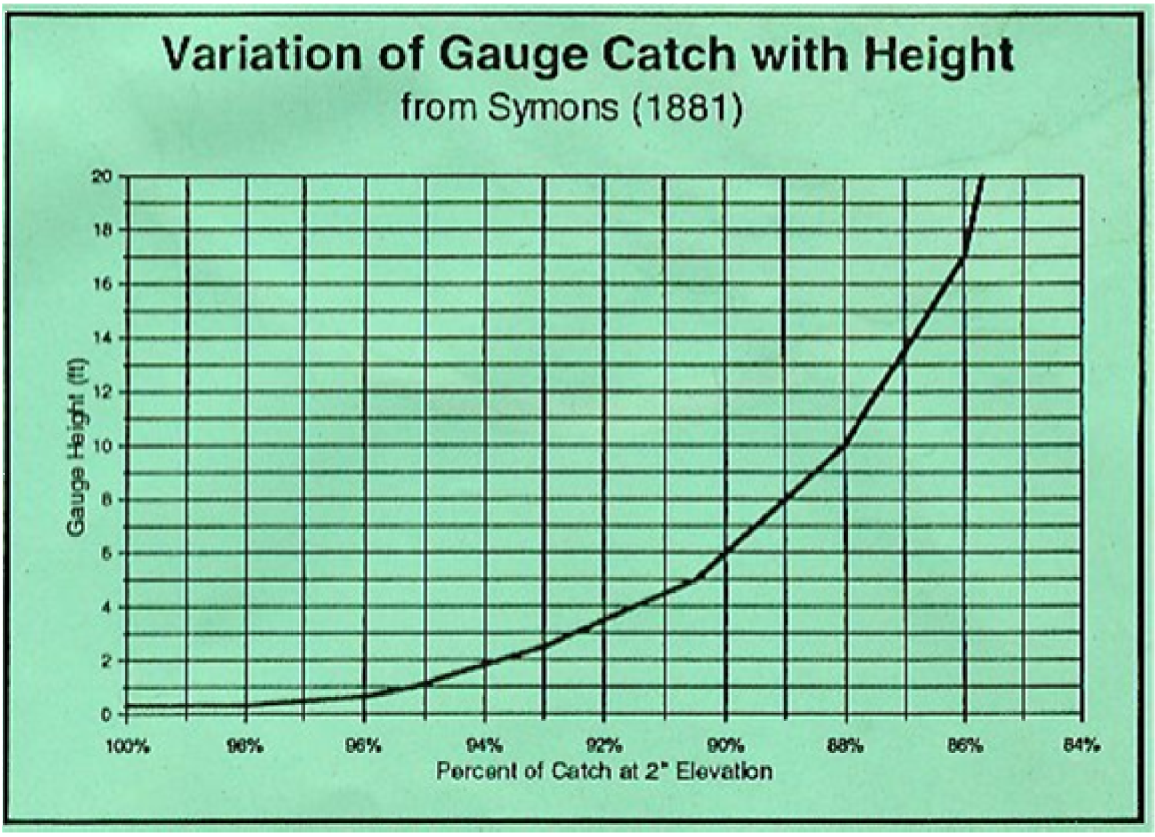
16.1 General

1. All new rainfall stations either recording or non-recording should be set on the WMO standard level (1 m above ground level). All stations should be installed at sites where no buildings, trees or vegetation may act as an obstacle, as the distance from nearby objects must be twice the height of the object from the rainfall station.
2. If a hydrometric station has no recorder, a set of 3 staff gages that would be of the maximum level reading staff gage type, should be installed along the river bank 100 m apart, in order to be able to compute the maximum discharge by the slope – area method. It is also recommended to have the same installation type at stations with recorders to be used in case of the recorder being stopped to function.
3. The river cross section should be surveyed every year prior to the onset of Monsoon and a fresh discharge (Q) v/s depth graph be prepared.
4. It is recommended to install a hydrometric station having a recorder with data logger on all major rivers and its principal tributaries.
5. If a hydrometeorological station does not have a recorder, flow measurements should be based on at least 3 water levels readings every 2 hours. During major floods, it is even recommended to have more readings.

6. A climatology (meteorological) station should be installed in the vicinity of any major or medium reservoir in order to establish direct rainfall over the reservoir and its surface evaporation.
7. A climatologic (meteorological) station should be positioned according to WMO standards (not on the roof of buildings). If it is installed at a higher elevation, a correction factor, as per the note given below, should be applied to correct the rainfall measurement.
8. In any major or medium reservoir the daily/monthly water balance should be based on the information gathered at the dam site having details similar to the available information of Rana Pratap Sagar (Chambal River): Reservoir inflow, reservoir outflow (spills, irrigation and other water supply releases), rainfall, evaporation, water level, capacity – water level relationship.
9. The rainfall should be measured hourly during rainy days.
10. Rainfall data should be checked and if necessary corrected by application of the Double Mass Curve technique.
11. Missing rainfall data should be filled by using regression analysis procedure or any other appropriate method.
12. The stream flow data should be checked by analysis of the rating curves that were applied, their consistency and if necessary also the current meter measurements that were the basis of the rating curve drawing. If rating curves were established based on float or non-direct methods (e.g. using the Manning formula) – the method applied should be noted.
13. In any major or medium reservoir, sediment measurements should be performed in order to update the water level / volume relationship. This exercise should be done at least once in 10 years.
14. Virgin flows should be prepared for any site whose records would be used for the rainfall – runoff calibrations.
15. Proper protection measures should be introduced in order to avoid potential damages to the equipment in order to determine the corrective measures.
16. During inspection of the site the damages should be defined and the repairs decided.
17. The distance of obstructive vegetation or any other object and their heights should be measured.
18. The system installed in 1999 by the company Min Data, Australia cannot be revived except SRRG: The technology used is not known to anybody, no software of that system is available. The equipments installed in remote areas were left unattended. They have either been in damaged or stolen. They are not in use since more than eight years. Therefore restoring this system will involve lot of expenditure these will have to be replaced by new equipment, and with the technology prevailing at present. Therefore the consultant agrees with new installation, given in Para 18. However, a few of the SRRGs of old system can be upgraded as mentioned in Para 18 and should be properly guarded and maintained

Note

a. According to studies carried out by the National Weather Service of the National Oceanic and Atmospheric Administration, the height of a rain gauge above the ground affects the measured rainfall. The following graph shows the percentage variation of measured rainfall as a function of its height above ground level.



b. All the raingauge stations (manual or SRRG) and the AWS be checked before June every year by an officer not below the rank of Assistant Engineer according to an agreed inspection check-list. (Table 16.1) One check list should be used for one station and all the checklists after completion of inspections should be kept in the Divisional office. The Divisional officer should submit a consolidated certificate of these inspections to the head of the Department (WRD) i.e. the Chief Engineer WRD Rajasthan; pointing out the bottlenecks in the equipment if any and also the suggestions to remove the bottle necks.

Table 16.1 Check list for Inspection of Weather and Meteorological Equipments

S. No.	Type of Equipment	Location					Tick the Condition		Height above Ground Level (m)	Nearby Structure (Bldg./Pole/Tree)		Are the chart records okay (Y/N)	Type of Damage if Damaged	Are measuring Cylinders as per Standard (Yes/No)	Are the Data Loggers working (Yes/No)	Are the Batteries Charged (Yes /No)	Are the Solar Panels working & undamaged (Yes/No)	Are the cables well Connected and undamaged (yes/No)	If the equip. Is installed above GL then whether correction factor is being applied (Yes/No)	Is the reading taking personal trained / qualified (Yes/No)	Is the equipment properly protected and guarded (Yes/No)	Any other deficiency noticed
		Nearby Village/ structure	Latitude	Longitude	District	Tehsil / Block	Working	Non-working		Height	Distance From the Equipment											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	Rain Gauge (manual)																					
2	Self Recording Rain Gauge (SRRG)																					
3	Water Level Recorder (WLR)																					
4	Humidity Recorder																					
5	Temperature Recorder																					
6	All Weather Station																					
a	Wind Velocity																					
b	Wind Direction																					
c	Solar radiations																					
d	Temperature																					
e	Humidity																					
f	SRRG																					
7	River Gauging																					
a	Cable Type (Float Type)																					
b	Gauge recording Type (manual)																					

16.2 As per WMO Recommendations

Based on the above-mentioned recommendations, the following may be presented for the state of Rajasthan.

a. According to the WMO recommendations (Table 14.1 above), in the mountainous parts with an area of 55,000 km^2, there should be at least 44 non-recording stations and at least 13 self rainfall recorders (Total number of the present non recording and recording rain gauges in the mountainous parts is 21 only).

b. According to the WMO recommendations (Table 14.1), in hilly undulating and interior plains with an area of 287,000 km^2 there should be at least 363 non-recording stations and at least 41 self rainfall recorders (Total number of the present non recording and recording rain gauges in this part is 558).

c. According to the WMO recommendations (Table 14.1), gives the number of the rain recorders that should be installed in urban areas 66 in total. At present, 108 recorders are installed in urban areas (urban area means towns having a population of more than 100,000).

d. Considering 36 AWSs and 29 observatories of IMD and one SRRG of CWC at Banswara, the final conclusion is that the state of Rajasthan has to add 37 raingauge stations in the Mountainous parts and 62 nos. of raingauges in hilly – undulating and interior plains and dams to meet with WHO norms, the details of which are given in Table 17.1. The locations of proposed raingauges (ARG or SRRG and Non SRRGs) are listed in Table 18.1, 18.2 and 18.3.

e. According to the WMO recommendations (Table 14.2), at least 7 evaporation stations should be installed in Rajasthan. Such information is required at each one of the major or medium-size projects in order to establish the water balance of the reservoirs. A weather station that includes either direct evaporation measurement facility (Class A pan) or indirect one (measurements of temperatures, relative humidity, wind patterns and solar radiation, etc.) can be defined as an evaporation station. However, there is a sufficient number (30 nos.) of indirect evaporation measurement facilities in the State and a few direct measurement facilities also in research farms and in IGNP.

f. According to the WMO recommendations (Table 14.4), at least 7 sediment stations should be installed in the mountainous and Hilly parts and at least 15 in the interior plains. Recommendations for sediment studies are given in Para 16.1 above (Point no.13).

g. For reservoirs to be regarded as hydrometric stations, all water balance components such as inflows, outflows, direct rainfall, evaporation and percolation should be measured at the site.

h. In designing new hydro-meteorological networks in the State, the HP (2003)9 recommendations should be followed.

17. Proposed Additional Rainfall Stations

The following table 17.1 presents the number of recording and non-recording rainfall stations proposed by the Consultants.

The table gives basin-wise the total number of proposed new rainfall stations without referring to their locations. The proposed sites were selected so as to increase the density of raingauge sites in areas where the present density is low, while also considering their proximity to villages or towns, from where the observator can conveniently access the rain gauges. If value of required number of station was less than 1, a single station was recommended.

The total number of the proposed raingauge stations is 99, of which 25 are self recording and 74 non-self recordings.

Table 17.1 Basin-wise Existing and Proposed Network of Rain gauge Stations in Mountainous and Non-mountainous parts of the state as per W.M.O. norms

S. No.	Basin Name	Basin Area, km^2	Hilly, Undulating And Mountainous Area, km^2	Hilly and Undulating Area, km^2	Mountainous Area, km^2	Non-Mountainous Area, km^2	No. of Stations required in Mountainous Area		No. of Stations required in Non-Mountainous Area		Existing No. of Stations in Mountainous Area		Existing No. of Stations in Non-Mountainous Area		Additional No. of Stations required in Mountainous Area		Additional No. of Stations required in Non-Mountainous Area	
							Rec.	Non - Rec.	Rec.	Non - Rec.	Rec.	Non-Rec.	Rec.	Non - Rec.	Rec.	Non-Rec.	Rec.	Non - Rec.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Shekhawati	9,691.10	5,149.41	4,614.41	535.00	9,156.09	1	2	2	16	1	0	1	15	0	2	1	1
2	Ruparail	2,550.22	1,935.71	1,716.50	219.21	2,331.01	1	1	1	4	1	0	0	11	0	1	1	0
3	Banganga	9,949.47	5,239.12	4,375.07	864.06	9,085.41	1	3	2	16	1	0	2	41	0	3	0	0
4	Gambhir	4,934.15	1,793.31	1,618.11	175.20	4,758.95	1	1	1	8	0	1	1	17	1	0	0	0
5	Parbati	1,890.95	-	-	-	1,890.95	0	0	1	3	0	0	1	5	0	0	0	0
6	Sabi	4,614.95	1,751.62	1,490.28	261.34	4,353.62	1	1	1	8	0	0	0	11	1	1	1	0
7	Banas	46,902.43	10,130.38	8,772.45	1,357.93	45,544.50	1	5	8	79	2	1	5	142	0	4	3	0
8	Chambal	31,229.83	5,344.34	4,014.87	1,329.47	29,900.36	1	5	5	52	1	3	5	72	0	2	0	0
9	Mahi	16,597.84	10,554.42	8,058.25	2,496.17	14,101.67	1	10	2	25	0	1	5	52	1	9	0	0
10	Sabarmati	4,117.72	4,066.76	2,284.89	1,781.87	2,335.84	1	7	1	4	0	3	0	6	1	4	1	0
11	Luni	69,579.83	6,179.23	4,521.96	1,657.27	67,922.56	1	7	12	118	0	3	4	79	1	4	8	39
12	West Banas	1,835.30	1,750.46	1,355.60	394.86	1,440.44	1	2	1	3	1	2	0	7	0	0	1	0
13	Sukli	993.63	224.06	193.22	30.84	962.80	1	0	1	2	0	0	0	1	1	0	1	1
14	Other Nallahs of Jalore	1,774.69	-	-	-	1,774.69	0	0	1	3	0	0	0	2	0	0	1	1
15	Ghaggar	5,201.51	-	-	-	5,201.51	0	0	1	9	0	0	1	7	0	0	0	2
16	Outside basin	130,400.19	881.18	786.79	94.39	130,305.80	1	0	1	13	0	0	5	60	1	0	0	0
	Total	342,263.80	55,000.00	43,802.39	11,197.61	331,066.20	13	44	41	363	7	14	30	528	7	30	18	44

Rec. – Recording; Non-Rec. – Non Recording

18. Proposed Modernization of Hydro-Meteorological Observatories

18.1 Introduction

Para 13 describes the status of existing meteorologic and hydrologic measurement stations in Rajasthan, as evaluated by the Consultants after carrying out inspections of representative climatological and hydrometric facilities. From this information it is evident that almost all Water Level Recorders (WLRs), All Weather Stations (AWS) and river discharge measurement equipment installed by the Australian company MinData have become defunct. Observations from these stations have not being collected for the last 6-7 years (2012). RWRD have concluded that these instruments cannot be brought back to operational conditions and in 2010 planned in to install new equipment on dam and river sites. A cost estimate was sanctioned for these instruments and to procure them tenders were also issued. But due to some reasons this procurement did not materialize. The Consultants also consider that the 2010 proposal by RWRD should be implemented so as to have a sound hydrometeorological information system.

18.2 Recommendations

It is suggested that

a. some existing sites be improved, rehabilitated and upgraded,
b. some new sites for river discharge observation be established, and
c. similarly, new dam observation stations be installed on selected important dams in Rajasthan covering most of the river basins.

18.3 Proposed New Rainfall Gauging Stations and Rehabilitation of Existing Ones

It is proposed to install 8 new self rainfall recording gauges (SRRG) and rehabilitate or upgrade 13 existing sites. The list of these 21 stations is given in Table 18.1 below. Eight new sites are proposed at Ajmer (Shekhawati river basin), Jaipur (Banas basin), Lalsot in Dausa District (Banas basin), Patan Tank, Todgarh and Mandalgarh in Bhilwara District (Banas basin), Bhopal Sagar in Chittorgarh District (Banas basin) and Baran in Chambal basin. Apart from the list of stations given in Table 18.1, some additional SRRGs are proposed in Table 18.2 to meet with WMO norms in mountainous and non-mountainous areas. Similarly non-self recording rain gauges have also been proposed as per WMO norms, in mountainous and non-mountainous area and given in Table 18.3.

18.4 River Observation Stations

19 new river observation sites are proposed at various locations in Banas basin, Chambal basin, Mahi basin and Sabarmati basin. These sites and their locations are listed in Table 18.4.

18.5 Dam Observation Stations

It is proposed to install water level recorders at 83 dams and canals, covering 12 river basins. On dams two types of water level recorder, i.e. Shaft Encoder type and Bubbler type are proposed, whereas for measurement of discharge in canals only the Bubbler type WLRs are proposed. Table 18.5 gives details of the location and type of equipment required at each station.

Table 18.1 Proposed Additional Hydrometeorological Observation Stations

S. No.	Basin Name	Location	WRIS Code	District	Water Resources Division	Latitude	Longitude	Type	Where to be Installed	Data Logger	VSAT	GSM Handset
1	2	3	4	5	6	7	8	9	10	11	12	13
New Stations												
1	Shekhawati	Ajmer	971	Ajmer	Ajmer	26°26'60"	74°37'12"	ARG	WRD Office	1	1	1
2	Banas	Jaipur	972	Jaipur	Jaipur	26°51'36"	75°48'36"	ARG	WRD Office	1	1	1
3	Banas	Lalsot	973	Dausa	Dausa	26°34'12"	76°19'48"	ARG	WRD Office	1	1	1
4	Banas	Patan Tank	974	Bhilwara	Bhilwara	25°55'12"	74°22'12"	ARG	WRD Office	1	1	1
5	Banas	Todgarh	975	Bhilwara	Bhilwara	25°41'60"	73°58'12"	ARG	WRD Office	1	1	1
6	Banas	Mandalgarh	976	Bhilwara	Bhilwara	25°13'12"	75°05'60"	ARG	WRD Office	1	1	1
7	Banas	Bhopal Sagar	977	Chittorgarh	Chittorgarh	24°52'12"	74°12'00"	ARG	WRD Office	1	1	1
8	Chambal	Baran	978	Baran	Baran	25°06'00"	76°31'12"	ARG	WRD Office	1	1	1
Upgrading of Existing Stations												
9	Ruparail	Bharatpur	-	Bharatpur	Bharatpur	27°13'12"	77°28'48"	ARG	WRD Office	1	1	1
10	Gambhir	Shri Mahavirji	-	Karauli	Karauli	26°41'60"	76°55'12"	ARG	WRD Office	1	1	1
11	Sabi	Sodawas	-	Alwar	Alwar	27°51'00"	76°22'48"	ARG	WRD Office	1	1	1
12	Banas	Kanota	-	Jaipur	Jaipur	26°52'48"	75°55'12"	ARG	WRD Office	1	1	1
13	Banas	Sarwar	-	Ajmer	Ajmer	26°04'48"	75°00'00"	ARG	WRD Office	1	1	1
14	Banas	Bhilwara	-	Bhilwara	Bhilwara	25°21'00"	74°37'48"	ARG	WRD Office	1	1	1
15	Banas	S.Madhopur	-	Sawai Madhopur	Sawai Madhopur	25°58'48"	76°22'12"	ARG	WRD Office	1	1	1
16	Banas	Chittorgarh	-	Chittorgarh	Chittorgarh	24°52'48"	74°37'48"	ARG	WRD Office	1	1	1
17	Chambal	Dholpur	-	Dholpur	Dholpur	26°41'60"	77°54'00"	ARG	WRD Office	1	1	1
18	Mahi	Dhariawad	-	Pratapgarh	Jakham Project Dn. Dhariawad	24°06'00"	74°28'48"	ARG	WRD Office	1	1	1
19	Mahi	Banswara	-	Banswara	Banswara	23°33'00"	74°27'00"	ARG	WRD Office	1	1	1
20	Luni	Jalore	-	Jalore	Jalore	25°21'00"	72°37'12"	ARG	WRD Office	1	1	1
21	West Banas	Mount Abu	-	Sirohi	Sirohi	24°36'00"	72°43'12"	ARG	WRD Office	1	1	1
									Total	21	21	21

ARG – Automatic Rain Gauge

Table 18.2 Additional Self Rainfall Recording Stations

S. No.	River Basin	Location	WRIS Code	District	W.R. Division	Latitude	Longitude	Region
1	Shekhawati	Kishangarh Renwal	979	Jaipur	Jaipur	27º94'38"	75º21'32"	Non Mountainous
2	Ruparail	Bagar Meo	980	Alwar	Alwar	27º31'40"	76º44'41"	Non Mountainous
3	Gambhir	Gudhachandraji	981	Karauli	Karauli	26º47'13"	74º41'16"	Mountainous
4	Sabi	Neemrana	982	Alwar	Alwar	27º59'40"	76º23'21"	Mountainous
5	Mahi	Garhi	983	Banswara	Banswara	27º53'20"	76º34'48"	Mountainous
6	Sabarmati	Khajurna	984	Udaipur	Udaipur	24º14'50"	73º18'16"	Mountainous
7	Sabarmati	Undithal	985	Udaipur	Udaipur	24º34'24"	73º30'21"	Non Mountainous
8	Luni	Bijpur	986	Pali	Sumerpur	25º57'70"	73º27'36"	Non Mountainous
9	Luni	Merta	987	Nagaur	Merta	26º36'54"	74º20'30"	Non Mountainous
10	Luni	Balotra	988	Barmer	Jodhpur	25º49'19"	72º14'28"	Non Mountainous
11	Luni	Sojat	989	Pali	Pali	25º53'36"	73º39'14"	Non Mountainous
12	Luni	Luni Chawn	990	Jodhpur	Jodhpur	26º00'46"	72º59'22"	Non Mountainous
13	Luni	Shergarh	991	Jodhpur	Jodhpur	26º20'17"	72º17'18"	Non Mountainous
14	Luni	Sheo	992	Barmer	Jodhpur	26º12'54"	71º15'24"	Non Mountainous
15	Luni	Jaswantpura	993	Jalore	Jalore	24º48'24"	72º27'21"	Non Mountainous
16	Luni	Rudhana	994	Ajmer	Ajmer	25º52'35"	74º10'31"	Mountainous
17	West Banas	Jhadoli	995	Sirohi	Sirohi	24º49'27"	73º10'52"	Non Mountainous
18	Sukli	Anadra	996	Sirohi	Sirohi	24º37'22"	72º38'29"	Non Mountainous
19	Sukli	Shergaon	997	Sirohi	Sirohi	24º41'01"	72º48'12"	Mountainous
20	Other Nallah of Jalore	Marwar Ratanpura	998	Jalore	Jalore	25º22'10"	72º40'50"	Non Mountainous
21	Out Side	Jaisalmer	999	Jaisalmer	Jodhpur	26º53'36"	70º54'29"	Mountainous

All these self recoding rain gauges are proposed to have configuration of control and operation with all network components such as, sensors, data loggers, VAST, GSM handsets etc.

Table 18.3 Additional Non-Self Recording Rainfall Stations

S. No.	River Basins	Location (Village)	WRIS Code	Block	Districts	W.R. Division	Latitude	Longitude	Region
1	2	3	4	5	6	7	8	9	10
1	Shekhawati	Singhana	896	Buhana	Jhunjhunun	Sikar	25º05'41"	75º51'13"	Non Mountainous
2	Shekhawati	Gadrata	897	Khetri	Jhunjhunun	Sikar	27º55'07"	75º47'19"	Mountainous
3	Shekhawati	Manaksas	898	Udaipurwati	Jhunjhunun	Sikar	27º46'12"	75º38'03"	Mountainous
4	Ruparail	Ghatla	899	Umren	Alwar	Alwar	27º43'37"	76º37'06"	Mountainous
5	Banganga	Mallana	900	Rajgarh	Alwar	Alwar	27º12'58"	76º24'53"	Mountainous
6	Banganga	Todi Ka Bas	901	Rajgarh	Alwar	Alwar	27º07'25"	76º18'41"	Mountainous
7	Banganga	Chandwaji	902	Amber	Jaipur	Jaipur	27º13'03"	75º56'23"	Mountainous
8	Sabi	Viratnagar (m)	903	Viratnagar	Jaipur	Jaipur	27º25'52"	76º11'20"	Mountainous
9	Banas	Khodmal	904	Jawaja	Ajmer	Ajmer	25º50'15"	74º02'41"	Mountainous
10	Banas	Reechher	905	Kumbhalgarh	Rajsamand	Rajsamand	25º11'34"	73º42'54"	Mountainous
11	Banas	Khidarpur Jadoo	906	Khandar	Sawai Madhopur	Sawai Madhopur	26º08'20"	76º36'45"	Mountainous
12	Banas	Biloli Nadi	907	Bonli	Sawai Madhopur	Sawai Madhopur	26º13'10"	76º33'17"	Mountainous
13	Mahi	Kotwal	908	Pratapgarh	Chittaurgarh	Chittaurgarh	23º58'37"	74º31'03"	Mountainous
14	Mahi	Gara Kumhariya	909	Aspur	Dungarpur	Dungarpur	23º50'40"	73º59'01"	Mountainous
15	Mahi	Teeri	910	Girwa	Udaipur	Udaipur	24º20'10"	73º40'20"	Mountainous
16	Mahi	Jagat	911	Girwa	Udaipur	Udaipur	24º22'13"	73º54'25"	Mountainous
17	Mahi	Soma Khra	912	Girwa	Udaipur	Udaipur	24º22'57"	74º03'24"	Mountainous
18	Mahi	Rikhabdeo (CT)	913	Kherwara	Udaipur	Udaipur	24º04'06"	73º41'00"	Mountainous
19	Mahi	Deola	914	Dhariyawad	Pratapgarh	Pratapgarh	23º59'21"	74º15'55"	Mountainous

S. No.	River Basins	Location (Village)	WRIS Code	Block	Districts	W.R. Division	Latitude	Longitude	Region
1	2	3	4	5	6	7	8	9	10
20	Mahi	Kel ki Kui	915	Lasadiya	Udaipur	Udaipur	24º13'38"	74º17'15"	Mountainous
21	Mahi	Keora Kalan	916	Sarada	Udaipur	Udaipur	24º27'24"	76º29'43"	Mountainous
22	Sabarmati	Peepla	917	Kotra	Udaipur	Udaipur	24º40'55"	73º14'45"	Mountainous
23	Sabarmati	Choki	918	Kotra	Udaipur	Udaipur	24º17'23"	73º15'28"	Mountainous
24	Sabarmati	Bhar Kunda	919	Kotra	Udaipur	Udaipur	24º44'58"	73º21'29"	Mountainous
25	Sabarmati	Adiseri	920	Kotra	Udaipur	Udaipur	24º28'20"	73º09'44"	Mountainous
26	Luni	Modawas	921	Dhorimanna	Barmer	Jodhpur	25º18'53"	71º46'27"	Non Mountainous
27	Luni	Koshloo	922	Sindhari	Barmer	Jodhpur	25º28'53"	71º44'29"	Non Mountainous
28	Luni	Mithora	923	Siwana	Barmer	Jodhpur	25º34'06"	72º10'28"	Non Mountainous
29	Luni	Sinli Chauseera	924	Balotra	Barmer	Jodhpur	25º47'16"	72º03'14"	Non Mountainous
30	Luni	Dhanaoo	925	Chohtan	Barmer	Jodhpur	25º13'00"	71º08'17"	Non Mountainous
31	Luni	Dhorimanna	926	Dhorimanna	Barmer	Jodhpur	25º12'32"	71º26'53"	Non Mountainous
32	Luni	Mahabar	927	Barmer	Barmer	Jodhpur	25º40'47"	71º25'19"	Non Mountainous
33	Luni	Harupechiyon Ki Dhan	928	Baytoo	Barmer	Jodhpur	25º51'27"	71º32'36"	Non Mountainous
34	Luni	Ramderiya	929	Sheo	Barmer	Jodhpur	26º20'26"	71º34'31"	Non Mountainous
35	Luni	Kanor	930	Baytoo	Barmer	Jodhpur	26º04'42"	71º46'30"	Non Mountainous
36	Luni	Simar Khiya	931	Baytoo	Barmer	Jodhpur	26º11'11"	72º04'52"	Non Mountainous
37	Luni	Mandli	932	Balotra	Barmer	Jodhpur	26º09'40"	72º30'52"	Non Mountainous
38	Luni	Sankhlon Ki Dhani	933	Balotra	Barmer	Jodhpur	25º56'08"	72º34'19"	Non Mountainous
39	Luni	Phalsoond	934	Sankra	Jaisalmer	Jodhpur	26º24'05"	71º57'09"	Non Mountainous
40	Luni	Bhaniyana	935	Sankra	Jaisalmer	Jodhpur	26º37'42"	71º50'45"	Non Mountainous

S. No.	River Basins	Location (Village)	WRIS Code	Block	Districts	W.R. Division	Latitude	Longitude	Region
1	2	3	4	5	6	7	8	9	10
41	Luni	Dadoki	936	Raniwara	Jalore	Jalore	24º50'27"	72º15'38"	Non Mountainous
42	Luni	Dantiwas	937	Bhinmal	Jalore	Jalore	24º58'21"	72º04'08"	Non Mountainous
43	Luni	Jhab	938	Sanchore	Jalore	Jalore	25º01'17"	71º50'48"	Non Mountainous
44	Luni	Tanpi	939	Sanchore	Jalore	Jalore	24º52'01"	71º27'05"	Non Mountainous
45	Luni	Mengalwa	940	Sayla	Jalore	Jalore	25º17'33"	72º13'02"	Non Mountainous
46	Luni	Takhtpura	941	Jalor	Jalore	Jalore	25º10'30"	72º44'47"	Non Mountainous
47	Luni	Raniwara	942	Jalor	Jalore	Jalore	25º12'05"	72º27'12"	Non Mountainous
48	Luni	Bhadrajoon	943	Ahore	Jalore	Jalore	25º35'52"	72º53'35"	Non Mountainous
49	Luni	Kui Jodha	944	Balesar	Jodhpur	Jodhpur	26º25'02"	72º27'01"	Non Mountainous
50	Luni	Ummednagar	945	Osian	Jodhpur	Jodhpur	26º33'32"	73º01'58"	Non Mountainous
51	Luni	Khejarla	946	Bilara	Jodhpur	Jodhpur	26º18'38"	73º40'08"	Non Mountainous
52	Luni	Gura Vishnoiyan	947	Luni	Jodhpur	Jodhpur	26º07'46"	73º04'42"	Non Mountainous
53	Luni	Gothan	948	Merta	Nagaur	Merta	26º38'29"	73º43'47"	Non Mountainous
54	Luni	Beetan	949	Merta	Nagaur	Merta	26º29'27"	73º50'29"	Non Mountainous
55	Luni	Riyan Bari	950	Riyan	Nagaur	Merta	26º31'39"	74º13'07"	Non Mountainous
56	Luni	Lampolai	951	Riyan	Nagaur	Merta	26º38'19"	74º11'22"	Non Mountainous
57	Luni	Ren	952	Merta	Nagaur	Merta	26º45'21"	74º06'25"	Non Mountainous
58	Luni	Harnawa	953	Parbatsar	Nagaur	Merta	26º53'41"	74º30'48"	Non Mountainous
59	Luni	Ugarpura	954	Kuchaman City	Nagaur	Merta	27º09'50"	74º50'20"	Non Mountainous
60	Luni	Chanod	955	Sumerpur	Pali	Pali	25º30'51"	73º06'31"	Non Mountainous
61	Luni	Dayalpura	956	Pali	Pali	Pali	25º41'55"	73º10'27"	Non Mountainous
62	Luni	Neembara	957	Rani	Pali	Pali	25º33'11"	73º26'38"	Non Mountainous

S. No.	River Basins	Location (Village)	WRIS Code	Block	Districts	W.R. Division	Latitude	Longitude	Region
1	2	3	4	5	6	7	8	9	10
63	Luni	Bagri	958	Raipur	Pali	Pali	25º53'37"	74º07'35"	Non Mountainous
64	Luni	Jaitiyawas	959	Bawari	Jodhpur	Jodhpur	26º44'26"	73º06'36"	Non Mountainous
65	Luni	Birantiya Khurd	960	Raipur	Pali	Pali	26º07'39"	74º09'13"	Mountainous
66	Luni	Rad Jhatra	961	Marwar Jn.	Pali	Pali	25º43'28"	73º54'25"	Mountainous
67	Luni	Gudha Gopinath	962	Desuri	Pali	Pali	25º25'49"	73º45'03"	Mountainous
68	Luni	Sadri Rural	963	Desuri	Pali	Pali	25º07'03"	73º26'00"	Mountainous
69	Chambal	Dhakni	964	Hindoli	Bundi	Bundi	25º28'49"	75º33'31"	Mountainous
70	Chambal	Taraj	965	Khanpur	Jhalawar	Jhalawar	24º31'24"	76º29'43"	Mountainous
71	Sukli	Nagani	966	Reodar	Sirohi	Sirohi	24º42'34"	72º35'57"	Non Mountainous
72	Other Nallahs of Jalore	Sewara	967	Raniwara	Jalore	Jalore	24º46'36"	72º01'59"	Non Mountainous
73	Ghaggar	14 KSP	968	Hanumangarh	Hanumangarh	Hanumangarh	29º27'58"	74º21'12"	Non Mountainous
74	Ghaggar	75000 RD	969	Pilibanga	Hanumangarh	Hanumangarh	29º18'53"	74º09'25"	Non Mountainous

All these rainfall recording gauges should be installed as per procedure and standards laid down in I.S. code no. - 5255: 1992 and I.S. 4986-2002.

Table 18.4 River Observation Stations

S. No.	Basin Name	Location	District	Latitude	Longitude	Shaft Encoder Float Type On River for Discharge measurement[16]	Bubbler	Data Logger	VSAT	Type of existing WLR	Availability of Bridge / Cableway	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Banas	Banas at Bigod	Bhilwara	25°15'20"	75°02'51"	1		1	1	Float Type	-	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
2	Banas	Bearch at Barliyas	Chittorgarh	25°11'38"	74°54'09"	1		1	1	Float Type	Cable way	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
3	Banas	D/s of Tunnel, Dewas stage-1	Udaipur	24°14'24"	75°52'48"		1	1	1		Bridge	New to be installed
4	Chambal	U/s of Rajgarh Dam	Baran	24°34'12"	76°47'24"		1	1	1			New to be installed
5	Chambal	U/s of Andheri Dam	Baran	25°16'59"	76°43'09"		1	1	1			New to be installed
6	Chambal	U/s of Hathiadeh Dam	Baran	24°50'37"	76°46'40"		1	1	1			New to be installed

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[16] It is proposed to replace all float type by pressure transducer or by a laser sensor facility or by a radar water level reader facility (see following photos of such facilities)

S. No.	Basin Name	Location	District	Latitude	Longitude	Shaft Encoder Float Type On River for Discharge measurement[16]	Bubbler	Data Logger	VSAT	Type of existing WLR	Availability of Bridge / Cableway	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
7	Chambal	Parvati pick-up Weir	Baran	24°42'21"	76°33'04"	2(1 D/s River & 1 on Canal)		1	1	Float Type	-	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
8	Chambal	Shergarh Pick-up Weir	Baran	25°30'23"	76°00'59"	3 (1 D/s River & 1 on Canal)		1	1			Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
9	Chambal	Mej at Jhaliji ka Barana	Bundi	24°28'22"	76°13'03"	1		1	1	Float Type	Cable way	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
10	Chambal	Kalisindh u/s of Dam	Jhalawar	24°37'47"	76°03'20"		1	1	1		Dam	New to be installed
11	Chambal	Ahu at Suket	Jhalawar	24°13'54"	76°48'27"	1		1	1	Bubbler Type	Bridge	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)

S. No.	Basin Name	Location	District	Latitude	Longitude	Shaft Encoder Float Type On River for Discharge measurement[16]	Bubbler	Data Logger	VSAT	Type of existing WLR	Availability of Bridge / Cableway	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
12	Chambal	Parwan at Manohar Thana	Jhalawar	24°08'13"	75°53'08"	1		1	1	Pressure Transducer 2100 P Type	Cable way	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
13	Chambal	Ahu at Awar	Jhalawar	24°40'42"	76°11'34"	1		1	1	Bubbler Type	Cable way	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
14	Chambal	Harish Sagar (Kali Sindh Pick-up Weir)	Jhalawar	24°28'56"	76°13'24"	2(1 D/s River & 1 on Canal)		1	1	Pressure Transducer 2100 P Type		Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
15	Mahi	Som River	Udaipur	23°57'55"	74°04'18"		1	1	1		Bridge	New to be installed
16	Mahi	Jakham at Nagalia Pick-up Weir	Pratapgarh	24°09'24"	74°31'36"	1		1	1	Float Type	Dam	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)

S. No.	Basin Name	Location	District	Latitude	Longitude	Shaft Encoder Float Type On River for Discharge measurement[16]	Bubbler	Data Logger	VSAT	Type of existing WLR	Availability of Bridge / Cableway	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
17	Mahi	Junction point of Hiran & Anas River, Near PH-2, Leelwani	Banswara	24°08'60"	74°28'03"			1	1		Bridge / Causeway	New to be installed
18	Sabarmati	Wakal River	Udaipur	24°15'19"	73°17'53"	1		1	1	Pressure Transducer 2100 P Type	Cable way	Existing Stilling Well to be used along with new instrument (Shift Encoder Float Type)
19	Sabarmati	Sabarmati Project	Udaipur	24°16'54"	73°03'44"		1	1	1			New to be installed
		Total				15	8	19	19			

Examples of radar-based water level sensors

Table 18.5 Dam Observation Stations

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ruparail	Jai Samand Bund	Alwar	Alwar	27°31'03"	76°32'05"	3.05	1	1		2*	1	1	1
2	Ruparail	Sikri Bund	Dausa	Dausa	27°34'00"	77°01'60"	Less than 10.00	1	1		1	1	1	1
3	Banganga	Mangalsar Dam	Alwar	Alwar	27°14'33"	76°23'27"	16.77	1		2*	2*	1	1	1
4	Banganga	Ajan Bund Dam	Bharatpur	Deeg	27°08'40"	77°30'26"	3.96	1		1	3*	1	1	1
5	Banganga	Madho Sagar Dam	Dausa	Dausa	26°50'32"	76°39'01"	10.67	1		2*	2*	1	1	1
6	Banganga	Moroli Bund Dam	Dausa	Dausa	26°45'49"	76°30'27"	Less than 10.00	1		1	1	1	1	1
7	Banganga	Sainthal Sagar Dam	Jaipur	Jaipur	27°01'48"	76°15'38"	9.76	1		1	2*	1	1	1
8	Gambhir	Baretha Dam	Bharatpur	Bharatpur	26°53'53"	77°22'19"	2.74	1		1	3*	1	1	1
9	Gambhir	Juggar Dam	Karauli	Karauli	26°43'16"	77°05'49"	8.54	1		1	1	1	1	1
10	Gambhir	Panchana Dam	Karauli	Karauli	26°33'46"	77°00'17"	11.59	1		2*	1	1	1	1
11	Gambhir	Bishan Samand Dam	S.Madhopur	S.Madhopur	26°49'31"	76°49'46"	7.93	1		1	1	1	1	1
12	Parvati	Parbati Dam	Dholpur	Dholpur	26°37'40"	77°26'52"	11.13	1		2*	1	1	1	1
13	Parvati	Ram Sagar Dam	Dholpur	Dholpur	26°36'11"	77°35'05"	8.38	1		1*	1	1	1	1

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[17] AWS = Automated Weather Station

[18] VSAT = Very Small Aperture Terminal

[19] GSM = Global System for Mobile Communication

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	Parvati	Urmila Sagar Dam	Dholpur	Dholpur	26°39'12"	77°45'24"	9.30	1		1	1	1	1	1
15	Sabi	Buchara Dam	Jaipur	Jaipur	27°35'24"	75°57'55"	18.29	1	1	1*	1	1	1	1
16	Banas	Narain Sagar Dam	Ajmer	Dn.-I Ajmer	25°56'16"	74°33'32"	5.49	1	1		2*	1	1	1
17	Banas	Lassaria Dam	Ajmer	Dn.-I Ajmer	26°02'43"	75°12'41"	0.99	1		1	1	1	1	1
18	Banas	Sareri Dam	Bhilwara	Dn.-I Bhilwara	25°41'39"	74°34'08"	Less than 10.00	1		1	2*	1	1	1
19	Banas	Umed Sagar Dam	Bhilwara	Dn.-I Bhilwara	25°12'02"	76°45'25"	37.96	1		2*	2*	1	1	1
20	Banas	Kothari Dam	Bhilwara	Dn.-I Bhilwara	25°19'00"	74°59'46"	Less than 10.00	1	1		2*	1	1	1
21	Banas	Arwar Dam	Bhilwara	Dn.-I Bhilwara	25°48'23"	74°48'29"	Less than 10.00	1		1	2*	1	1	1
22	Banas	Meja Dam	Bhilwara	Dn.-II Bhilwara	25°23'36"	74°32'26"	Less than 10.00	1		1	0	1	1	1
23	Banas	Matrikundia Dam	Bhilwara	Dn.-II Bhilwara	25°02'07"	74°18'52"	Less than 10.00	1		1	2*	1	1	1
24	Banas	Badgaon Dam	Chittorgarh	Dn.-II Chittorgarh	24°42'27"	74°05'20"	9.15	1		1	1	1	1	1
25	Banas	Bassi Dam	Chittorgarh	Dn.-I Chittorgarh	25°01'54"	74°49'22"	14.5	1		2*	1	1	1	1
26	Banas	Banas Basin	Chittorgarh	Dn.-I Chittorgarh	24°41'60"	74°43'00"	8.54	1		1	2*	1	1	1
27	Banas	Orai Dam	Chittorgarh	Dn.-II Chittorgarh	24°50'40"	74°47'04"	39.00	1		2*	1	1	1	1
28	Banas	Wagon Dam	Chittorgarh	Dn.-I Chittorgarh	24°29'44"	74°24'17"	Less than 10.00	1		1	2*	1	1	1
29	Banas	Morel Dam	Dausa	Dn. Dausa	26°26'49"	76°20'04"	11.59	1	1	1*	2*	1	1	1

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
30	Banas	Chaparwara Dam	Jaipur	Dn. Jaipur	26°37'14"	75°15'21"	6.10	1	1		3*	1	1	1
31	Banas	Kalisil Dam	Karauli	Dn. Karauli	26°16'09"	76°46'02"	9.66	1		1	1	1	1	1
32	Banas	Nandsamand Dam	Rajsamand	Dn. Rajsamand	24°55'21"	73°46'49"	11.28	1		2*	2*	1	1	1
33	Banas	Rajsamand Dam	Rajsamand	Dn. Rajsamand	25°04'08"	73°52'32"	10.67	1	1	1*	2*	1	1	1
34	Banas	Moran Sagar Dam	S.Madhopur	Dn. S.Madhopur	26°39'48"	76°32'21"	5.18	1		1	3*	1	1	1
35	Banas	Surwal Dam	S.Madhopur	Dn. S.Madhopur	26°04'55"	76°20'25"	4.57	1		1	1	1	1	1
36	Banas	Galwa Bund	Tonk	Dn. Tonk	25°52'60"	76°01'00"	7.01	1		1	1	1	1	1
37	Banas	Mashi Dam	Tonk	Dn. Tonk	26°24'39"	75°45'29"	6.34	1	1		1	1	1	1
38	Banas	Tordi Sagar Dam	Tonk	Dn. Tonk	26°12'33"	75°25'06"	10.06	1	1		3*	1	1	1
39	Banas	Bisalpur Dam	Tonk	Const. Dn-III B.P. Deoli	25°55'28"	75°27'21"	13.00	1		2*	2*	1	1	1
40	Banas	Bagolia Dam	Udaipur	Const. Dn. Udaipur	24°48'58"	73°57'14"	7.77	1		1	2*	1	1	1
41	Banas	Vallabh Nagar Dam	Udaipur	Const. Dn. Udaipur	24°38'31"	74°17'09"	7.93	1		1	2*	1	1	1
42	Chambal	Gopalpura Dam	Baran	Dn.-I Baran	25°09'57"	76°44'01"	2.67	1		1	2*	1	1	1
43	Chambal	Umed Sagar Dam	Baran	Dn.-I Baran	25°11'34"	76°45'33"	Less than 10.00	1		1	4*	1	1	1
44	Chambal	Vilas Dam	Baran	Dn.-I Baran	25°03'00"	76°49'60"	Less than 10.00	1		1	1	1	1	1
45	Chambal	Bethli Dam	Baran	Dn.-II Baran	24°37'00"	76°58'00"	Less than 10.00	1		1	2*	1	1	1

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
46	Chambal	Hindlot Dam	Baran	Dn.-II Baran	25°16'60"	76°43'00"	Less than 10.00	1		1	1	1	1	1
47	Chambal	Lhasi Dam	Baran	Dn.-II Baran	24°34'60"	76°42'00"	Less than 10.00	1		1	1	1	1	1
48	Chambal	Chakan Dam	Bundi	Project Dn. Bundi	25°48'00"	76°13'60"	Less than 10.00	1		1	1	1	1	1
49	Chambal	Bundi Ka Gothara	Bundi	Dn. Bundi	25°04'18"	76°01'57"	8..23	1		1	1	1	1	1
50	Chambal	Gararda Dam	Bundi	Project Dn. Bundi	25°16'60"	75°31'00"	18.90	1		1	2*	1	1	1
51	Chambal	Dugari Dam	Bundi	Dn. Bundi	25°41'51"	75°52'48"	4.50	1		1	1	1	1	1
52	Chambal	Bardha Dam	Bundi	Project Dn. Bundi	25°14'36"	75°57'52"	Less than 10.00	1		1	2*	1	1	1
53	Chambal	Gudha Dam	Bundi	Dn. Bundi	25°29'36"	75°27'45"	12.04	1	1	1*	1	1	1	1
54	Chambal	Gagrin Dam	Jhalawar	Chauli Canal Dn. Jhalawar	24°07'60"	75°54'00"	Less than 10.00	1		1	1	1	1	1
55	Chambal	Chhapi Dam	Jhalawar	Chappi Dn. Jhalawar	24°20'34"	76°28'22"	15.30	1		2*	2*	1	1	1
56	Chambal	Bhim Sagar Dam	Jhalawar	Jhalawar	24°33'45"	76°20'05"	13.41	1		2*	2*	1	1	1
57	Chambal	Chauli Dam	Jhalawar	Chauli Canal Dn. Jhalawar	24°14'43"	76°05'38"	Less than 10.00	1		1	2*	1	1	1
58	Chambal	Piplad Dam	Jhalawar	Chauli Canal Dn. Jhalawar	24°30'35"	75°55'53"	Less than 10.00	1		1	2*	1	1	1
59	Chambal	Parwan Dam	Jhalawar	Jhalawar	24°42'47"	76°33'19"	25.91	1		2*	2*	1	1	1
60	Chambal	Kota Barrage Dam	Kota	Chambal Proj. Dn. Kota	25°10'33"	75°49'36"	24.94	1		2*	2*	1	1	1

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
61	Chambal	Alnia Dam	Kota	Chambal Proj. Dn. Kota	25°00'10"	75°52'44"	10.65			2*	2*	1	1	1
62	Chambal	Sawan Bhado Dam	Kota	Kota	24°49'18"	76°05'49"	13.60	1		1	1	1	1	1
63	Chambal	Rana Pratap Sagar Dam	Kota	Chambal Proj. Dn. Kota	24°54'60"	75°35'35"	11.28	1		1*	0	1	1	1
64	Chambal	Jawahar Sagar Dam	Kota	Chambal Proj. Dn. Kota	25°02'14"	25°02'14"	15.55	1	1	1*	0	1	1	1
65	Chambal	Takali Dam	Kota	Kota	24°46'01"	75°54'14"	4.55	1	1	1	2*	1	1	1
66	Mahi	Surwania Dam	Banswara	S.E. Mahi Proj. Const. Circle Banswara	23°29'27"	74°21'56"	Less than 10.00	1		1	1	1	1	1
67	Mahi	Mahi Dam	Banswara	S.E. Mahi Proj. Const. Circle Banswara	23°37'42"	74°32'49"	22.50	1	1	1*	3*	1	1	1
68	Mahi	Lodisar ka Naka dam	Dungarpur	Dungarpur	23°39'57"	73°54'56"	7.62	1		1	2*	1	1	1
69	Mahi	Som Kamla Amba	Dungarpur	Som Kamla Amba Dn. Dungarpur	23°58'42"	74°01'58"	13.00	1	1		2*	1	1	1
70	Mahi	Jakham Dam	Pratapgarh	Jakham Pro. Dn. Dhariyawad	24°10'12"	74°35'25"	43.15	1		2*	0	1	1	1
71	Mahi	Daia Dam	Udaipur	Salumber	24°19'55"	73°48'38"	13.75	1		2*	1	1	1	1

S. No.	Basin Name	Location	District	W.R. Division	Latitude	Longitude	Maximum Water Height in m	AWS[17]	Water Level Recorder		Bubbler on Canal for discharge Measurement	Data Logger	VSAT[18]	GSM[19] Handset
									Shaft Encoder on Dam	Bubbler on Dam				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
72	Mahi Basin	Jaisamand Dam	Udaipur	Salumber	24°14'29"	73°57'13"	9.60	1	1		2*	1	1	1
73	Mahi	Somkagdar Dam	Udaipur	Salumber	24°01'42"	73°37'42"	19.28	1	1	1*	1	1	1	1
74	Sabarmati	Sei Dam	Udaipur	Udaipur	24°43'09"	73°11'55"	Less than 10.00	1		1	1 (on Tunnel)	1	1	1
75	Luni	Bankli Bund	Jalore	Jalore	25°42'49"	72°55'36"	8.54	1	1		2*	1	1	1
76	Luni	Jaswant Sagar Dam	Jodhpur	Jodhpur	26°13'38"	73°41'21"	12.04	1		2*	1	1	1	1
77	Luni	Sardar Samand Dam	Pali	Pali	25°58'46"	73°23'06"	9.15	1	1		1	1	1	1
78	Luni	Raipur Luni Dam	Pali	Pali	26°01'21"	74°03'50"	7.32	1		1	1	1	1	1
79	Luni	Hemawas Dam	Pali	Pali	25°43'57"	73°20'10"	9.76	1	1		2*	1	1	1
80	Luni	Jawai Bund	Pali	Jawai Canal Dn. Sumerpur	25°05'05"	73°09'09"	18.67	1	1	1*	1	1	1	1
81	Luni	Ora Dam	Sirohi	Jawai Canal Dn. Sumerpur	25°01'36"	72°48'33"	8.84	1		1	1	1	1	1
82	West Banas Basin	West Banas Dam	Sirohi	Sirohi	24°41'60"	72°55'60"	8.46	1	1		2*	1	1	1
83	Other Nallah in Jalore District	Jetpura Dam	Jalore	Jalore	24°39'43"	72°17'15"	Less than 10.00	1		1	1	1	1	1
		Total						82	22	87	130	83	83	83

* These stations are having Sensors situated at different banks for canals and on down stream of dams, therefore an appropriate wireless technology confirming to Indian Laws for transferring data of these stations to the data logger should be used.

18.6 Summary and Conclusions

According to the above proposals, Table 18.6 summarizes the total number of instruments required along with tentative cost of these instruments.

Table 18.6 Summary of Proposed Instruments and Tentative Cost

S. No.	Particulars	Number	Unit Cost, Rs.	Total Cost, Rs.
1.	Self Recording Raingauge Stations	29	35,000	1,015,000
2.	Non-Self Recording Raingauge Stations	74	2,500	185,000
3.	Automatic weather sensors (AWS)	82	160,000	13,120,000
4.	Shaft Encoder type water level sensors	37	25,000	925,000
5.	Bubbler type water level sensors	225	185,000	41,625,000
6.	VSAT at DAC at remote stations including cost of software	123	350,000	43,050,000
7.	GSM Handsets	104	2,000	208,000
8.	Data loggers	123	50,000	6,150,000
9.	Portable GPS	6	12,000	72,000
10.	Portable Profile Mappers (ADCP) on river	4	800,000	3,200,000
11.	Solar panels, charge regulators batteries station ground systems	47	40,000	1,880,000
Total				111,430,000
			Say 111.43 Million Rs.	

Note: Maintenance cost can be taken as following percentage of total cost – 10% in first year, 13% in second year and 15% in third year.

In addition, Data Acquisition Centres (DAC) will have to be established at the State Capital, Jaipur (Sinchai Bhawan, JLN Marg), where a compatible web server for VSAT network will be installed along with complete computer system – LCD 29” and 60”, solar panels, charge regulators, batteries and station grounding systems with UPS, etc. Moreover, a computer room in all the 48 RWRD Divisions will have to be prepared. This computer room will have computers with UPSs, printers, telephones, etc. At the time of procurement RWRD should also reserve at least 10% of the above-mentioned equipment as spare stock. RWRD should also receive a comprehensive technology transfer for the various systems, and employees should be trained, who will be involved in handling these systems and equipment.

It should not be forgotten that quality is an important characteristic of data. It is better to spend more money on a few stations then to try to spread a limited budget over many stations by using lowcost equipments or providing inadequate inspections. The value of data network is determined in the last analysis by the amount of useful information it produces. Without an effective organization of data, the continuing tasks of servicing and inspection will not be well managed, and an otherwise well-planned network will be unproductive. The department should also strengthen itself for checking of reliability of data which should be done as soon as possible after the data are collected. Data should also be published from time to time. Publication also provides insurance against loss or damage to original records.

19. Action Plan based on Recommendations

An Action Plan has been prepared based on various recommendations presented in earlier sections and presented in Table 19.1

Table 19.1 Action Plan based on Recommendations

S. No.	Recommendations	Proposed Actions	Anticipated Value Addition	Responsibility
1	Installation of new Rain - Gauge stations	It is proposed to install 103 nos. new Rain Gauge stations, and upgrade/rehabilitate 13 nos. existing Rain Gauge stations. Out of 103 nos. new Rain Gauge stations (8+21) 29 nos. are self recording and 74 nos. are Non-self recoding. 13 nos. existing Rain Gauge stations are also self recording, which are proposed for upgradation or rehabilitation. **(for details refer Table 18.1, 18.2 and 18.3 of Volume 1 of this report)**	To increase the density of rain gauge sites in areas where the present density is low, while also considering their proximity to villages or towns, from where the observator can conveniently access the rain gauge stations.	SWRPD and WRD
2	Installation of new Dam Observation Stations	It is proposed to install water level recorders at 83 dams and canals, covering 12 river basins. On dams two types of water level recorder (WLR), i.e. Shaft Encoder type and Bubbler type WLRs are proposed. At each location Automatic Weather Station (AWS) is also proposed. **(for details refer Table 18.5 of Volume 1 of this report)**	Proper accounting of inflows.	SWRPD and WRD
3	Installation of new and improvement in existing River Gauge & Discharge (G&D) sites	It is proposed to install 19 new and improve the existing River Gauge & Discharge (G&D) sites in various basins/ sub-basins. The final recommendation on this aspect has been given in Final Report No. 4.2. **(for details refer Table 18.4 of Volume 1 of this report)**	Better accounting of surface water flow in rivers and improvement in available database.	SWRPD and WRD

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Appendices

Appendix 1

Descriptive Note on Integrated Water Resource Management (IWRM) and Adaptation to Climate Change

1. Introduction

The National Water Mission (NWM) has recognised integrated water resources management (IWRM) at the basin level as the foundation upon which the implementation of adaptation to climatic change can be realised. It is very likely that a particular agroclimatic zone may contain one or more river basins or conversely a river basin might have areas belonging to different agroclimatic zones. Therefore for assessing water supply and demand, a water balance approach is desirable, which needs to be taken up according to the hydrological boundaries of the catchment or basin. However, the agroclimatic zone can play an important role in studying the inherent characteristics of the land mass from the view point of agricultural management practices, crop suitability, etc.

Adopting management plans designed to respond to changes at the river-basin level requires a sound understanding of the present hydrological cycle, the range of human activities affecting the hydrological cycle and the communities dependent on the resources of the basin.

The internal hydrology of a basin needs to be assessed for water quantity, quality, and reliability, social change, water demand and the state of the ecosystems in relation and response to external drivers. This assessment also involves reviewing the current capacity to mitigate or adapt to changes, including climate change.

Application of IWRM principles at the scales of river basin or watershed is increasingly accepted worldwide as the way to overcome the considerable challenges being faced in the water resources sector. Although an ‘enabling’ institutional infrastructure is a desirable prerequisite for implementing IWRM, it is not enough for the practical execution of effective water management – that is, for the efficient and reliable delivery of water for hydropower, municipal and industrial water supply, irrigated agriculture, or even environmental flows. It is at the river basin scale that schemes, wide-ranging efforts such as coordination, collaboration and joint action are currently implemented.

2. The National Water Policy

The National Water Policy was adopted in September 1987 and then reviewed and updated, first in April 2002 and recently again in 2012. The National Water Policy provides for some of the amendments needed in the Inter State Water Dispute (ISWD) Act. Some of the features of the new National Water Policy (NWP, 2002, 2012) are as follows.

1. The National Water Policy provides for the formulation of river basin organisations. It also states that the “scope and powers of the river basin organisations shall be decided by the basin states themselves”. In the case of interstate rivers, such a move has never been made because of mistrust and the absence of a facilitator. This role may have to be entrusted to the Union government, if we want to manage the interstate rivers in the best possible manner.

2. It provides for the creation of a standardised national information system promoting free exchange of data among various agencies. Here it might be mentioned that as per the Sarkaria commission recommendations, a data bank and information system at the national level has to be set up at the earliest and the states shall be required to compulsorily make the necessary data available. However the ground realities show that data accessibility is the major constraint for individual researchers as well as organisations, which leads them to take case studies of international water bodies at the cost of providing solutions using state of the art technologies for the Indian systems.

3. It provides for "adequate safe drinking water facilities" without mentioning the quantity of water, in litres per capita per day, which should be provided at the urban and rural levels for various densities of population. There are recommendations for regular water quality monitoring of surface and ground water according to the national water quality standards.

4. The National Water Policy also recognises that water resource development should be planned for in hydrological units, or watersheds.

The National Commission for Integrated Water Resources Development Plan had recommended repealing the River Boards Act and enacting a new Act called the Integrated and Participatory Management Act. It is proposed that sustainability in the quantity and quality of water resources be achieved by taking into account multi-sectoral factors such as groundwater, surface water and other environmental considerations. Although the Act has not been passed as recommended, it has been reflected in the Environment Policy (EP, 2006). The EP also addresses many other issues, such as climate change and its impact on various sectors and the importance of exploring coping strategies.

3. What is "integration"?

3.1 General

Integrated water resources management does not merely imply the amalgamation of different activities to be undertaken within a hydrological unit. It also requires the collation of relevant information so as to evaluate the cause and effect of all the proposed actions. The watershed or catchment is the unit where the evaluation of man-induced impacts upon natural resources becomes possible with respect to the water balance approach. Therefore, although the district Panchayat remains the preferred implementation unit, the watershed or catchment should be the evaluation unit used in assessing impacts.

As the impacts resulting from actions taken at the watershed level will be experienced at a higher level within the drainage basin, the assessment of these impacts will require the availability of a framework which enables the mapping of such units and their entities, and the interconnections from the watershed level to the higher catchment level in the following hierarchy: river basin at the highest level of the drainage system, catchment at the intermediate level and the watershed at the lowest level. Such a framework will need regular maintenance and updating to fully reflect the most accurate ground-truth data and the data related to infrastructure requirements for planning and management of the natural resources, as collected by the relevant departments. This framework, once available, could be used by all the line departments and updated by the relevant departments which have designated areas of jurisdiction over data entry. The format should be made consistent with local to state and national level structures as well as the corresponding watershed, catchment and basin level structures. Such a framework shall also be used to enumerate the freshwater ecosystem services that each system is serving.

3.2 The River Basin as an Appropriate Unit for Integrated Management

- A basin-level perspective enables integration of downstream and upstream issues, quantity and quality, surface and ground water, land use and water resources in a practical manner.

- The basin-level perspective, defined by geographical and hydrological characteristics, facilitates the practical integration of downstream and upstream as well as basin-wide issues, and the incorporation of quantity and quality aspects of the basin’s available surface and ground water resources.

- Land uses in a river basin, such as urban development, agriculture and forest conservation, can have profound impacts on water resources in the basin and vice versa.

- A basin-level perspective allows water managers to effectively address the linkages between water resources management and the management of land and other related resources.

3.3 Integrated Management of Water Resources, Disasters and Environmental Issues

- Proper management of water resources offers increased flexibility in facilitating and supporting natural ecological functions and human activities by improving the resilience and robustness of those systems under a variety of stresses, including climate change.

- The seasonal and annual variability in quality and quantity of water that supports these diverse functions can be estimated through monitoring, analysis and assessment, thereafter incorporated into plans and operations. For example, operating rules for dams for controlling the storage for flood control, municipal water supply and hydropower, can be periodically modified to maximize their utility, while at the same time ensuring environmental flows.

4. Climatic Change Adaptation

4.1 Adaptation Measures

4.1.1 General

Forecasts of climate change may remain debatable for some time; evidence of increased climate variability is incontestable, and the severity of that variability demands urgent responses from water managers. The reassuring aspect of this argument is that adaptation options for coping with climate variability now will also help reduce the impact of climate change in the future. These measures include the conventional technological elements of water infrastructure, like storage reservoirs, boreholes, recharge wells and sand wells, but with an emphasis on techniques for boosting the yield of available resources (rainwater harvesting, water recycling and reuse, desalination). Adaptation benefits enormously from improved forecasting and climate modelling. This stresses the need for strengthening of data gathering initiatives (many hydrological stations in developing countries have become defunct over the years through lack of investment). Risk sharing and access to credit for affected families are among the financial mechanisms that are being adapted to be responsive to floods and droughts. On a more structural level, modification of land-use patterns, crop selection and tillage practices can also be considered.

The following table shows climate-change adaptation measures in developing countries as agreed upon in the UN convention on climate change in year 2007.

Table 1 Adaptation Measures in Key Vulnerable Sectors Highlighted in National Communications of Developing Countries (after United Nations Framework Convention on Climate Change, UNFCCC, 2007)

Vulnerable sectors	Anticipatory adaptation	Reactive adaptation
Water resources	- Better use of recycled water Conservation in catchment areas - Improved water management system - Water policy reform (pricing, irrigation policies) - Flood control, drought monitoring	- Protection groundwater resources - Improved management/ maintenance of water supply systems - Protection of catchments - Improved water supply - Ground and rainwater harvesting, desalinization
Agriculture and food security	- Development tolerant/resistant crops - Research and development - Soil-water management - Diversification/intensification food/plantation crops - Policy measures (tax incentives, subsidies, free markets) - Early warning systems	- Erosion control - Dams for irrigation - Fertilizer use and application - Introducing new crops - Soil fertility maintenance - Planting and harvesting times - Different cultivars - Education and outreach on soil/water conservation and

Vulnerable sectors	Anticipatory adaptation	Reactive adaptation
		management
Human health	- Early warning systems - Improved disease/vector surveillance/monitoring - Improvement environmental quality - Changes in urban/housing design	- Public health management reform - Improved housing/living conditions - Improved emergency response
Terrestrial ecosystems	- Creation of parks/reserves, protected areas, biodiversity corridors - Identification/development resistant species - Vulnerability assessment ecosystems - Species monitoring - Development/maintenance seed banks - Including socioeconomic aspects in management policy	- Improvement management systems, incl. deforestation, reforestation, aforestation - Promoting agroforestry - National forest fire management plans - Carbon storage in forests
Coastal zones and marine ecosystems	- Integrated coastal zone management - Coastal planning and zoning - Legislation for coastal protection - Research and monitoring of coasts and coastal ecosystems	- Protection of economic infrastructure - Public awareness for protection of coastal and marine ecosystems - Building seawalls and beach enforcement - Protection mangroves, coral reefs, sea grasses, littoral vegetation

Another distinction can be made with respect to the system in which adaptation takes place: the natural or human system. Within the human system a distinction can be made between public (governments at all levels) and private (individual households, commercial companies) interests (Table 2).

Table 2 Matrix showing five prevalent types of adaptation to climate change, including examples of adaptation

		Anticipatory	Reactive
Natural systems			· Changes in length of growing season · Changes in ecosystem composition · Wetland migration
Human systems	Private	· Purchase of insurance · Construction of houses on stilts · Redesign of oil-rigs	· Changes in farm practices · Changes in insurance premiums · Purchase of air-conditioning

	Public	· Early warning systems · New building codes, design standards · Incentives for re-location	· Compensatory payments, subsidies · Enforcement of building codes · Beach nourishment

Source: Klein, 1998; Smit et al., 2001, in UNFCCC, 2006

Finally, when getting into technologies for adaptation, a distinction can be made between soft and hard technologies (UNFCCC, 2006). Soft technologies include insurance, crop rotation, set-back zones as well as information and knowledge. Hard technologies could be seawalls, drought resistant seeds and irrigation technology. In many cases successful adaptation will include a mixture of soft and hard technologies. UNFCCC 2006 makes a further classification into traditional, modern, high and future technology.

It is questionable if society can rely on autonomous adaptation to deal with the expected impacts of climate change and increased variability. Thus, it is widely acknowledged that there is a need for anticipatory planned adaptation, which could take the following forms (Klein and Tol, 1997; Huq and Klein, 2003; in UNFCCC, 2006):

1. increasing the ability of infrastructure to resist impacts of climate change (e.g. reinforcing dikes);
2. increasing the flexibility of vulnerable systems managed by humans (e.g. changing management practices);
3. enhancing the adaptability of vulnerable natural systems (e.g. reducing other stresses);
4. reversing trends that increase vulnerability (e.g. reducing human activities in vulnerable areas, preserving natural systems that reduce vulnerability);
5. improving public awareness and preparedness (e.g. early warning systems).

Appleton (2004) gives an overview of options for adaptation grouped according to the following categories:

- robust policies,
- technological and structural measures and
- risk sharing and spreading

4.1.2 Robust Policies

Over centuries, societies and ecosystems have adapted to climate variability and climate change in an evolutionary way. Today, the rapidity of changes in hydrological regimes requires more immediate and more concerted efforts. Policies and operating rules focused on optimum exploitation of available water resources need to be adjusted. Sea level rise, shrinking natural lakes and desertification all force changes in land-use and livelihoods. The increasing susceptibility of flood plains to extreme events means that governments have to consider more rigid spatial planning as a coping option. Resettlement is neither popular nor desirable, but it may eventually become inevitable where the risk associated with a particular place may start to outweigh perceived benefits and therefore may become unacceptable to society.

The policy concepts and processes directly related to and considered applicable for the purpose of adaptation planning include integrated water resources management (IWRM) and integrated flood management (IFM). All these concepts are adaptive in nature and consider management options in broad development contexts. This is essential for the robustness of policies in the natural resource management context. Similarly, if ecosystem conservation or pollution control leads to narrow aim policies that prevent the necessary investments in water resources development, there are often unconsidered consequences on water availability under climate variability and change, as well as on food and livelihood security. Robust policies should therefore be based on the broad aims and principles of integrated water resources management and integrated flood management. The processes suggested by those concepts provide the means for mediating different interests and competing uses of water resources.

A fundamental aspect of any coping strategy therefore must be mainstreaming of climate issues into the national water management policy. To implement such policies there is the need to have a legal and institutional framework in place, in order to allow all stakeholders to become part of the process and manage the resources according to agreed rights, powers and obligations. An overview of policy instruments that can be used is presented in Table 3.

Table 3 Compendium of Policy Instruments for Adaptation
(adapted from Appleton, 2004)

International	National
International conventions on Climate Change (UNFCCC) International trade (particularly WTO) Polluter-pays principle influences ODA/Funds	National Poverty Reduction Strategies National strategic interests National Water Policies and IWRM Plans National Adaptation Plans of Action Disaster Management Policies National Drought Preparedness and Mitigation Plans Economic instruments and water markets Risk management cross-cutting in development plans Strengthened functions of River Basin Authorities Integrated catchment management Non-water planning, e.g. urban areas, refuges Adaptive spatial planning and resettlement Livelihood diversification (in particular for highly climate dependent sectors such as rainfed agriculture)
Regional	
Regional Adaptation Plans of Action Regional Strategic Action Plans for IWRM Trans-boundary plans and interstate cooperation Informal bi-national cooperation Regional institutions	

4.1.3 Technological and Structural Measures

The list of coping options in Table 4 below may seem like a catalogue of water management infrastructure and operating techniques. It is true that coping with climate change does not involve many entirely new processes or techniques, perhaps with the exception of advances in the structure, quality and resolution of climate information products such as seasonal or inter-annual climate predictions. It should, however, be made clear that this is not an argument for ‘business as usual’. Existing instruments, methods and measures may need to be introduced at a faster pace, and applied in different locations, at different scales, within different socio-economic contexts and in new combinations.

The message that there may be adaptation solutions for the water sector found in places that have experienced climatic conditions in the past, and that are now expected to become commonplace elsewhere, should be a driving principle of adaptation planning.

Table 4 Compendium of Technological and Structural Adaptation Options (adapted from Appleton, 2004)

Storage and Recirculation	Early Warning Systems
Large reservoirs	Near real time (hours to days)
Small reservoirs	Short-term (days to weeks)
Groundwater	Medium-term (month to season)
Artificial recharge	Long-term (years to decades)
Borehole drilling	Communicate forecasts to end-users
Sand dams	
Scavenger/gallery wells	Operations/system improvements
Related options	Reservoir operations rules
System maintenance	Integrated, optimised reservoir systems
Supply leakage control	Retrofitting existing structures
Irrigation equipment maintenance	Irrigation scheduling
Irrigation canal leakage	Water demand management
Rainwater harvesting	Indigenous coping strategies
Water re-use/recycling	Precipitation enhancement
Desalination	Soil conservation and tillage practices
Flood/storm surge control	Crop varieties
Structures (levees, dykes, diversions, detention basins)	
Preventative operations	

What it also means is reviewing existing operations in the light of very different hydrological circumstances. Basin infrastructure is essential to protect against, and reduce the impact of water-related disasters, along with new civil works like disaster shelters in risk-prone areas. It can be very practical to improve existing infrastructure, such as roads, drains, natural ponds and lakes, dams and reservoirs, and processes like soil conservation of steep slopes and sediment control into reservoirs. However, proper skills for operation and maintenance and the financial means to carry them out are equally important.

As far as specific management measures are concerned, as a general rule, reservoirs provide the most robust, resilient and reliable mechanism for managing water under a variety of conditions and uncertainties. However, other combinations of non-structural measures (e.g. demand management, agricultural conservation practices, pricing, regulation, relocation) may provide comparable outcomes in terms of gross quantities of water supply, but not necessarily in terms of system reliability. The choice of alternatives depends on the degree of social risk tolerance and perception of scarcity, as well as the complexity of the problem.

The possibilities for coping with the uncertainties of climate change and variability are manifold – both in the number of strategies and in the combinations of management measures that comprise a strategy. There is no single ‘best’ strategy. Each depends on a variety of factors, e.g. economic efficiency, risk reduction, robustness, resiliency or reliability. However, adaptation strategies need to be developed, implemented and monitored through participatory cross-sectoral policy processes such as integrated water resources management or integrated flood management. Only if this succeeds the resulting solutions to adapt practices in the water management and planning domain will have a chance to be socially equitable, economically efficient and environmentally sustainable. Furthermore, such process would need to be employed to minimize the risks that adaptation measures are counterproductive to the climate change mitigation agenda.

The hydrological rules have changed. Continually updated assessments of meteorological and hydrological data need to be an integral part of water resources planning and management. Continued efforts are required from the climatological and hydrological research communities to absorb those data and transform them into results adequate for adaptation planning.

4.1.4 Risk Sharing and Spreading

Disaster insurance is a classic means for dividing risks and losses among a higher number of people over a long-time period (see Table 5 below). Payouts on natural disasters are potentially massive, and very much higher than any single small or medium-sized insurance company could bear. For this reason, there is an active market in re-insurance. The cost of premiums can be very high for major infrastructure, and many governments do not take out insurance cover, choosing instead to bear the replacements cost of the partial losses that inevitably occur from their capital budgets. Provided long-run costs of replacement remain less than the cost of premiums, this is a sensible approach – for societies, this approach relies on Government investments in replacement. A major problem arises when a disaster is of such magnitude that it overwhelms the capacity of an economy to bear the cost from the national recurrent budget. Recognizing that climate-related hazards are not only inevitable, but are likely to continue increasing, insurance mechanisms are seen to have a role in sharing and spreading risks.

Table 5 Compendiums of Risk Sharing and Spreading Options
(Adapted from Appleton, 2004)

Insurance	Finance
Primary Insurers	Development Banks
Re-Insurance	Private
Micro-Insurance	Micro-Lenders

4.2 Adaptation Focus

4.2.1 Adaptation Focus 1: Integrated Water Resources Development and Management

Integrated water resources management (IWRM) is widely recognized as the most effective way to optimize water availability for all uses, although the institutional strengthening it demands poses challenges to many developing countries. With IWRM and its extension to integrated catchment management comes an increased flexibility to cope with large fluctuations in rainfall and river flows (Appleton, 2004).

Agricultural and irrigation technology have made it possible to continue feeding a world population that has tripled in the past century. On the negative side, many water management systems and policies are not well adapted to responding to the modern paradigm of water management that calls for managing the resource in a sustainable manner under conditions of uncertainty. The degree to which IWRM approach can be implemented and put into practice depends on the adaptive capacity of countries' institutions.

Increasing the production efficiency of water by improving irrigation efficiency is the simplest answer to water scarcity and climate variability. The initial step is to improve the water available within irrigation and drainage systems.

4.2.2 Adaptation Focus 2: Integrated Flood Management

Adaptation measures in the flood management context should involve a best mixture of structural and non-structural measures, with the aim of minimizing the losses of life from flooding and maximizing the net-benefits derived from the floodplains. This approach is also referred to as integrated flood management or flood management within the context of IWRM.

- Structural measures include for instance dams, levees, diversion channels, detention basins, flood proofing, etcetera.
- Non-structural measures include flood forecasting and warning systems, spatial planning, source-control, emergency preparedness and response procedures, insurance, flood risk awareness programmes, etcetera.

In recent years a number of countries have developed adaptation strategies to deal with more extreme flood events. Those strategies involved as a first step detailed scientific assessments of observed and projected change of climate variables and their expected impact on the water resources of the specific country. The strategies are generally based on the precautionary and risk management principles. Some countries have given consideration to adjust flood defences through introducing design factors or allowances to account for expected changes to river discharge, sea level, wave activity etc. Other countries are recommending a more diversified approach in the form of a combination of measures to allow flood defences to be overtopped during an extreme event without compromising their structural integrity and at the same time to minimize the residual flood risks through spatial planning, emergency preparedness and response programmes, as well as flood insurance.

River flood, flash flood or tidal flood:

Flood forecasting and warning systems are considered baseline systems for the protection of life and property in the context of climate variability and climate change. Many countries are lacking substantial capacity in that field and climate change places the establishment or improvement of such systems in a priority position. Such systems can be considered part of no-regret adaptation options, meaning their establishment is beneficial within a climate change scenario, but also when climate does not change.

Flood forecasting needs to encompass all stages and aspects of floods, such as water levels in rivers and floodplains (hydrological predictions), and projections of, for example, the damage to agriculture and infrastructure (economic or impact predictions). Long term hydrological forecasts typically have a lead time of a month or more. These can only give a general indication of whether there would be a risk of increased flooding, and if the predicted floods are likely to be average, below or above average. This information can however be of great value to reservoir operators in semi-arid regions. These hydrological predictions depend very strongly on forecasting accuracy for weather and climate on seasonal time scales. Medium term hydrological forecasts have a lead time of a week or so, and should provide more accurate estimates of the flood conditions. These forecasts mainly depend on the quality of rainfall forecasts and information from the upper watersheds, additional short term climate information, and the quality of a distributed hydrological model used to calculate runoff and river flows. Finally, short term hydrological forecasts, with a lead time of a few days, focus on river water levels and the extent and depth of inundation areas. This forecast is derived from a real-time observation of rainfall and river flows in the upper watershed, combined with hydrological and hydraulic models which calculate or estimate water levels in the river and water storage in the inundated areas (Appleton, 2004).

4.2.3 Adaptation Focus 3: Drought Preparedness and Mitigation

There are both traditional (indigenous) and technological approaches to coping with the risk of drought. Any technological management of drought requires medium (seasonal) to long-term (annual to decadal) climate forecasts and, therefore, the appropriate modelling tools. This information has then to be translated into early warning and response mechanisms.

Supply-side drought protection measures include the following.

- ✓ Supplies of water should be augmented by exploiting surface water and groundwater in the area. However, intensive groundwater withdrawal for drought management is not a sustainable remedy.

- ✓ Transfers can be made from surface water sources (lakes and rivers) and from groundwater, if socio-economically and environmentally acceptable.

- ✓ Storage of water can be increased. Groundwater reservoirs (aquifers) which store water, when available, can be more advantageous than surface water storage, despite the pumping costs, because of the reduction in evaporation losses.

In recent years the emphasis in action plans to combat drought has increasingly shifted from supply side management by provision of water resources in required quantities, to effective demand side management of the finite, and scarce, freshwater resource.

Possible demand-side measures include:

- improved land use practices,
- watershed management,
- rainwater and runoff harvesting,
- re-cycling water (e.g. use of treated municipal waste water for irrigation),
- development of water allocation strategies among competing demands,
- reduction of wastage, and
- improvements in water conservation via reduction of unaccounted-for water, water pricing and subsidies.

Drought contingency planning also requires thorough consideration, including:

- restrictions on water use,
- rationing schemes,
- special water tariffs, and
- reduction of low-value uses.

4.2.4 Adaptation Focus 4: Weather and Climate Information

Climate prediction and weather forecasting are vital elements in coping strategies. Meteorologists are getting better at tracking and forecasting extreme weather associated with cyclones and typhoons, with reasonable accuracy over periods of a few days or weeks. Increasing understanding of the El Niño and La Niña phenomena and other climate anomalies means that predicting seasonal climate variations for specific regions is also becoming more accurate. In this context regional climate outlook forums (RCOFs) have been instrumental in providing consensus seasonal climate outlooks before the onset of the rainy season to support climate adaptation in various sectors.

4.2.5 Adaptation Focus 5: Ecosystem Maintenance

Policy decisions at the governmental level for protecting the natural ecosystems from the adverse impacts of climate change need special attention. Effective responses depend on the understanding of the likely regional changes in the climate and ecosystem. Monitoring of those changes is essential to adjust management practices and can be considered no-regret options. The current state of knowledge suggests that the impacts on ecosystems from unmitigated climate change would be disastrous and unprecedented in human history, and that adaptation measures for ecosystems would only be effective for lower levels of climate change. Existing policies to protect and preserve the natural ecosystem would also be useful in a climate change regime.

Reducing the present stresses on the natural ecosystems such as habitat fragmentation and destruction, overexploitation, pollution and introduction of alien species will provide various ecosystems with some space and time to adjust within specific limits, and therefore need to be recognized as adaptation measures.

Some of the adaptation measures to protect natural ecosystem are (Global Water System Project GWSP, 2005):

- conservation of wild biodiversity: strengthening of protected area network,
- sustainable improvement in traditional agriculture to protect forest and meadows, and
- protection of fresh water wetlands.

Ecosystem services such as water purification, livelihood provision (particularly in a subsistence livelihood context), or flood mitigation may be negatively affected by climate change. However, the impact of climate change on those services is subject to ongoing research and may hold various surprises as climate change proceeds. The IPCC AR 4 indicates that drylands, mountain and Mediterranean regions may be most vulnerable. The IWRM process, based on the involvement of all stakeholders and the principles of environmental and ecological sustainability has the potential to integrate the fate of vital terrestrial and aquatic ecosystems for life support of future generations under climate change.

4.3 Benefits of Adaptation to Climate Change

A basin level perspective also becomes increasingly important in addressing global and local change issues, particularly as climate change impacts are realized through the response of the hydrological cycle, in terms of quality and quantity with direct impacts on the basin.

- Such changes may include increases in the number and severity of floods and droughts over current seasonal patterns.
- Climate change is the supply-side driver, which ultimately determines how much water is available, when and where – and ultimately how much we can use. It can lower environmental flows in rivers, affecting water availability, quality and other water functions such as sanitation, hydropower and navigation.
- In order to reasonably mitigate these anticipated climate impacts, it is even more essential to coordinate a variety of existing water management practices in a basin across all relevant sectors, and optimize operation of water infrastructure consistent with sustainable development goals and availability of water.

4.4 Adapting Management Plans to changes

Water resource systems are directly and indirectly affected by the interaction of numerous human related drivers of economic, social, and demographic functions. Water managers should understand how different drivers of change affect the hydrology and the related water demands, and the consequences to the basin inhabitants. Prioritizing adaptation responses to those changes is a key component of the IWRM process at the river basin level.

5. References

Appleton B. (Ed.), 2004. Climate changes the water rules: How water managers can cope with today's climate variability and tomorrow's climate change. Published in The Netherlands by the Dialogue on Water and Climate

GWSP, 2005. The Global Water System Project: Science Framework and Implementation. Earth System Science Partnership.

IPCC, 2007. ‘Climate Change 2007: Impacts, Adaptation and Vulnerability’, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, (eds)], Cambridge: Cambridge University Press http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf

Kabat P., Schulze R.E., Hellmuth M.E., Veraart J.A. (Eds), 2003. Coping with impacts of climate variability and climate change in water management: A scoping paper. DWC-Report no. DWCSSO-01 International Secretariat of the Dialogue on Water and Climate, Wageningen, Netherlands.

UNFCCC, 2006. Application of environmentally sound technologies for adaptation to climate change. Available from http://unfccc.int/resource/docs/2006/tp/tp02.pdf

UNFCCC, 2007. ‘Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries’. Available from http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/txt/pub_07_impacts.pdf

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE http://unfccc.int/resource/docs/convkp/conveng.pdf

Gosain A.K. Policy and practice analysis: assessing policy influences on people’s relationship to water ecosystem services. International Institute of Environment and Development (IIED).

Appendix 2
The SWAT Model

A. General

SWAT is the acronym for **S**oil and **W**ater **A**ssessment **T**ool, a river basin, or watershed, scale model developed by Dr. Jeff Arnold for the USDA Agricultural Research Service (ARS). SWAT was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time. To satisfy this objective, the model

- is physically based. Rather than incorporating regression equations to describe the relationship between input and output variables, SWAT requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring in the watershed. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. are directly modelled by SWAT using this input data.

  Benefits of this approach are
  - watersheds with no monitoring data (e.g. stream gage data) can be modelled
  - the relative impact of alternative input data (e.g. changes in management practices, climate, vegetation, etc.) on water quality or other variables of interest can be quantified
- uses readily available inputs. While SWAT can be used to study more specialized processes such as bacteria transport, the minimum data required to make a run are commonly available from government agencies.
- is computationally efficient. Simulation of very large basins or a variety of management strategies can be performed without excessive investment of time or money.
- enables users to study long-term impacts. Many of the problems currently addressed by users involve the gradual build-up of pollutants and the impact on downstream water bodies. To study these types of problems, results are needed from runs with output spanning several decades.

SWAT is a continuous time model, i.e. a long-term yield model. The model is not designed to simulate detailed, single-event flood routing.

B. Development of SWAT

SWAT incorporates features of several ARS models and is a direct outgrowth of the SWRRB[1] model (Simulator for Water Resources in Rural Basins) (Williams et al., 1985; Arnold et al., 1990). Specific models that contributed significantly to the development of SWAT were CREAMS[2] (Chemicals, Runoff, and Erosion from Agricultural Management Systems) (Knisel, 1980), GLEAMS[3] (Groundwater Loading Effects on Agricultural Management Systems) (Leonard et al., 1987), and EPIC[4] (Erosion-Productivity Impact Calculator) (Williams et al., 1984).

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[1] SWRRB is a continuous time step model that was developed to simulate nonpoint source loadings from watersheds.

Development of SWRRB began with modification of the daily rainfall hydrology model from CREAMS. The major changes made to the CREAMS hydrology model were: a) the model was expanded to allow simultaneous computations on several sub-basins to predict basin water yield; b) a groundwater or return flow component was added; c) a reservoir storage component was added to calculate the effect of farm ponds and reservoirs on water and sediment yield; d) a weather simulation model incorporating data for rainfall, solar radiation, and temperature was added to facilitate long-term simulations and provide temporally and spatially representative weather; e) the method for predicting the peak runoff rates was improved; f) the EPIC crop growth model was added to account for annual variation in growth; g) a simple flood routing component was added; h) sediment transport components were added to simulate sediment movement through ponds, reservoirs, streams and valleys; and i) calculations of transmission losses were incorporated.

The primary focus of model use in the late 1980s was water quality assessment and development of SWRRB reflected this emphasis. Notable modifications of SWRRB at this time included: a) incorporation of the GLEAMS pesticide fate component; b) optional SCS technology for estimating peak runoff rates; and c) newly developed sediment yield equations. These modifications extended the model’s capability to deal with a wide variety of watershed management problems.

In the late 1980s, the Bureau of Indian Affairs needed a model to estimate the downstream impact of water management within Indian reservation lands in Arizona and New Mexico. While SWRRB was easily utilized for watersheds up to a few hundred square km in size, the Bureau also wanted to simulate stream flow for basins extending over several thousand square km. For an area this extensive, the watershed under study needed to be divided into several hundred sub-basins. Watershed division in SWRRB was limited to ten sub-basins and the model routed water and sediment transported out of the sub-basins directly to the watershed outlet. These limitations led to the development of a model called ROTO (Routing Outputs to Outlet) (Arnold et al., 1995), which took output from multiple SWRRB runs and routed the flows through channels and reservoirs. ROTO provided a reach routing approach and overcame the SWRRB sub-basin limitation by “linking” multiple SWRRB runs together. Although this approach was effective, the input and output of multiple SWRRB files was cumbersome and required considerable computer storage. In addition, all SWRRB runs had to be made independently and then input to ROTO for the channel and reservoir routing. To overcome the awkwardness of this arrangement, SWRRB and ROTO were merged into a single model, SWAT. While allowing simulations of very extensive areas, SWAT retained all the features which made SWRRB such a valuable simulation model.

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[2] In response to the Clean Water Act, ARS assembled a team of interdisciplinary scientists from across the U.S. to develop a process-based, nonpoint source simulation model in the early 1970s. From that effort CREAMS was developed. CREAMS is a field scale model designed to simulate the impact of land management on water, sediment, nutrients and pesticides leaving the edge of the field. A number of other ARS models such as GLEAMS, EPIC, SWRRB and AGNPS trace their origins to the CREAMS model.

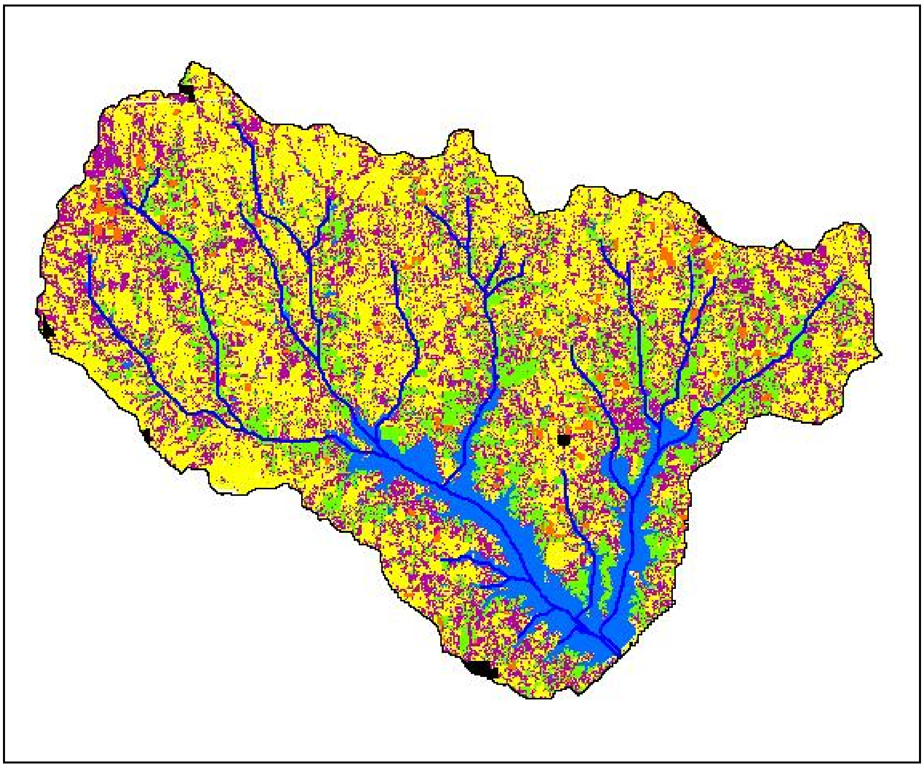
[3] GLEAMS is a nonpoint source model which focuses on pesticide and nutrient groundwater loadings.

[4] EPIC was originally developed to simulate the impact of erosion on crop productivity and has now evolved into a comprehensive agricultural management, field scale, nonpoint source loading model.

Since SWAT was created in the early 90s, it has undergone continued review and expansion of capabilities. The most significant improvements of the model between releases include:

- SWAT94.2: Multiple hydrologic response units (HRUs) incorporated
- SWAT96.2: Auto-fertilization and auto-irrigation added as management options; canopy storage of water incorporated; a CO_2 component added to crop growth model for climatic change studies; Penman-Monteith potential evapotranspiration equation added; lateral flow of water in the soil based on kinematic storage model incorporated; in-stream nutrient water quality equations from QUAL2E added; in-stream pesticide routing.
- SWAT98.1: Begin FORTRAN90 recode; snow melt routines improved; in-stream water quality improved; nutrient cycling routines expanded; grazing, manure applications, and tile flow drainage added as management options; model modified for use in Southern Hemisphere; urban build up/wash off equations from SWMM added along with regression equations from USGS.
- SWAT99.1: Bacteria transport routines added; rice/wetland routines improved; Green & Ampt infiltration added; weather generator improved.

Figure 1: Delineated Watershed



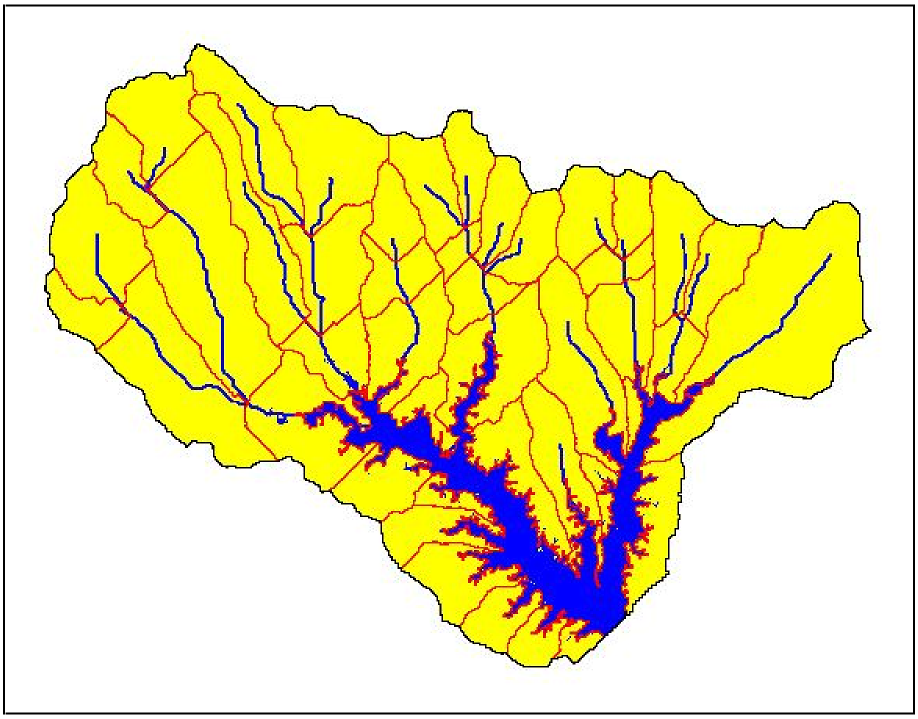
In addition to the changes listed above, interfaces for the model have been developed in Windows (Visual Basic), GRASS, and ArcView. SWAT has also undergone extensive validation.

C. Overview of SWAT

SWAT allows a number of different physical processes to be simulated in a watershed. These processes will be briefly summarized in this section.

For modelling purposes, a watershed may be partitioned into a number of sub-watersheds or sub-basins. The use of sub-basins in a simulation is particularly beneficial when different areas of the watershed are dominated by land uses or soils different enough in properties to impact hydrology. By partitioning the watershed into sub-basins, the user is able to relate different areas of the watershed to one another spatially. Figure 2 shows sub-basin delineation for the watershed shown in Figure 1.

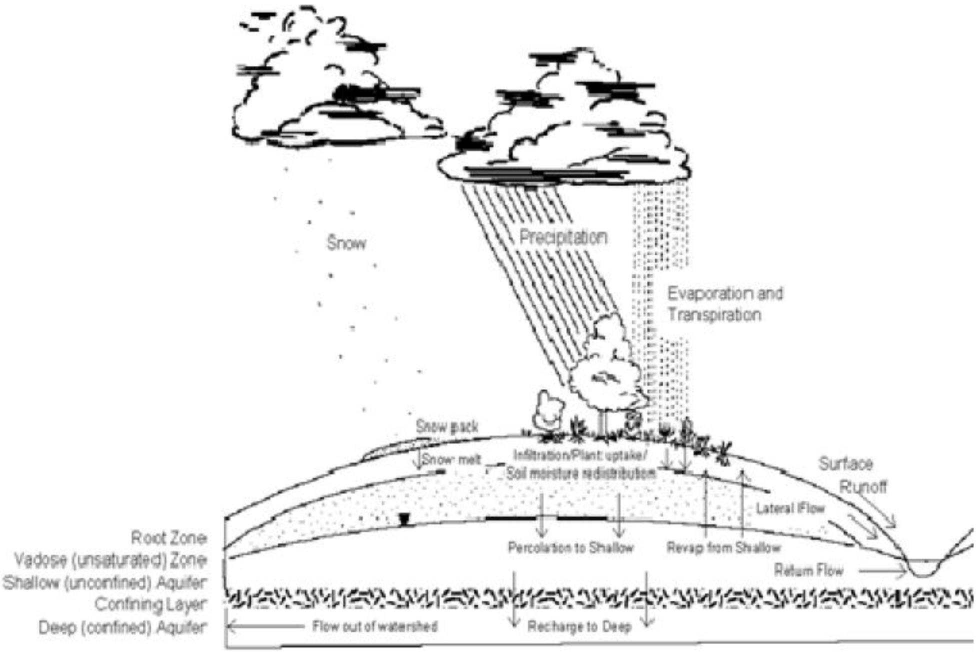
Figure 2: Sub-basin Delineation



Input information for each sub-basin is grouped or organized into the following categories: weather or climate; unique areas of land cover, soil, and management within the sub-basin (hydrologic response units or HRUs); ponds/reservoirs; groundwater; and the main channel, or reach, draining the sub-basin.

No matter what type of problem is studied with SWAT, water balance is the driving force behind everything that happens in the watershed. To accurately predict the movement of pesticides, sediments or nutrients, the hydrologic cycle as simulated by the model must conform to what is happening in the watershed. Simulation of the hydrology of a watershed can be separated into two major divisions. The first division is the land phase of the hydrologic cycle, depicted in Figure 3. The land phase of the hydrologic cycle controls the amount of water, sediment, nutrient and pesticide loadings to the main channel in each sub-basin. The second division is the water or routing phase of the hydrologic cycle which can be defined as the movement of water, sediments, etc. through the channel network of the watershed to the outlet.

Figure 3: Hydrologic Cycle



D. Land Phase of the Hydrologic Cycle

The hydrologic cycle as simulated by SWAT is based on the water balance equation:

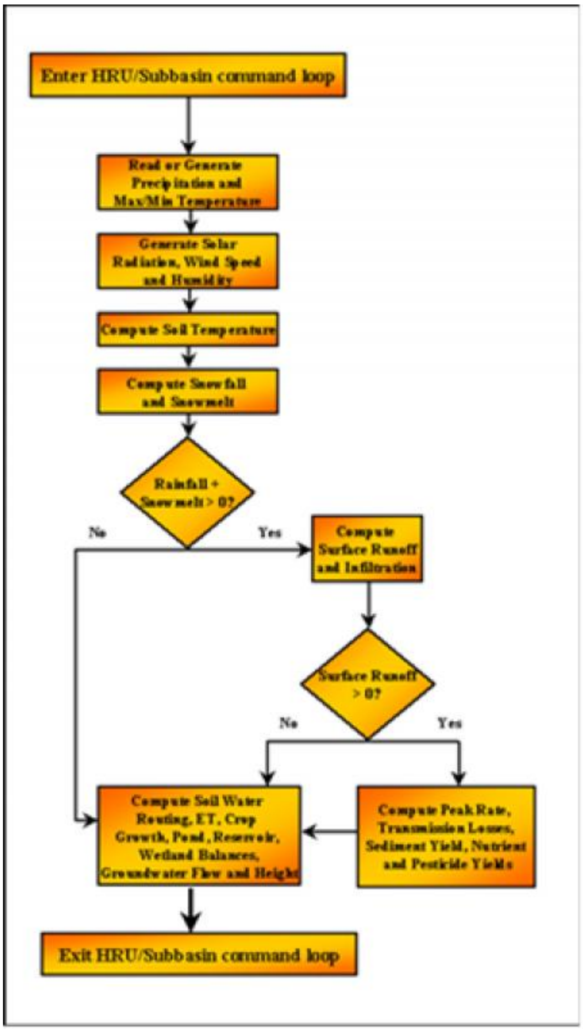
$$SW_t = SW + \sum_{i=1}^{t} (R_i - Q_i - ET_i - P_i - QR_i)$$

(1)

where	SW_t	is the final soil water content (mm),
	SW	is the soil water content available for plant uptake, defined as the initial soil water content minus the permanent wilting point water content (mm),
	t	is the time (days),
	R_i	is the amount of precipitation (mm),
	Q_i	is the amount of surface runoff (mm),
	ET_i	is the amount of evapotranspiration (mm),
	P_i	is the amount of percolation (mm), and
	QR_i	is the amount of return flow (mm).

The subdivision of the watershed enables the model to reflect differences in evapotranspiration for various crops and soils. Runoff is predicted separately for each HRU and routed to obtain the total runoff for the watershed. This increases accuracy and gives a much better physical description of the water balance.

Figure 4: General Sequence of Processes used by SWAT


Enter HRU/Subbasin command loop
Read or Generate Precipitation and Max/Min Temperature
Generate Solar Radiation, Wind Speed and Humidity
Compute Soil Temperature
Compute Snowfall and Snowmelt
Rainfall + Snowmelt > 0?
No
Yes
Compute Surface Runoff and Infiltration
Surface Runoff > 0?
No
Yes
Compute Soil Water Routing, ET, Crop Growth, Pond, Reservoir, Wetland Balances, Groundwater Flow and Height
Compute Peak Rate, Transmission Losses, Sediment Yield, Nutrient and Pesticide Yields
Exit HRU/Subbasin command loop

This figure shows the general sequence of processes used by SWAT to model the land phase of the hydrologic cycle. The different inputs and processes involved in this phase of the hydrologic cycle are summarized in the following sections.

E. Climate

The climate of a watershed provides the moisture and energy inputs which control the water balance and determine the relative importance of the different components of the hydrologic cycle.

The climatic variables required by SWAT consist of daily precipitation, maximum/minimum air temperature, solar radiation, wind speed and relative humidity. The model allows values for daily precipitation and maximum/minimum air temperatures to be input from records of observed data or generated during the simulation. Solar radiation, wind speed and relative humidity are always generated by the model.

a. Weather Generator

Daily weather values are generated from average monthly values. The model offers the option of generating one set of values to be used for the entire watershed or a set of weather data may be generated for each sub-basin. If weather values are generated for individual sub-basins, the values for any one sub-basin will be generated independently and there will be no spatial correlation of generated values between the different sub-basins.

i. Generated Precipitation

SWAT uses a model developed by Nicks (1974) to generate daily precipitation for simulations which do not read in measured data. This precipitation model is also used to fill in missing data in the measured records. The precipitation generator is based on a first-order Markov chain model which defines a day as wet or dry by comparing a random number (0.0-1.0) generated by the model to monthly wet-dry probabilities input by the user. If the day is classified as wet, the amount of precipitation is generated from a skewed normal distribution or a modified exponential distribution.

ii. Generated Air Temperature and Solar Radiation

Maximum and minimum air temperatures and solar radiation are generated from a normal distribution. A continuity equation is incorporated into the generator to account for temperature and radiation variations caused by dry vs. rainy conditions. Maximum air temperature and solar radiation are adjusted downward when simulating rainy conditions and upwards when simulating dry conditions. The adjustments are made so that the long-term generated values for the average monthly maximum temperature and monthly solar radiation agree with the input averages.

iii. Generated Wind Speed.

A model developed by Richardson and Wright (1984) is used to generate daily mean wind speed and direction given the mean monthly wind speed. This model is based on a modified exponential equation.

iv. Generated Relative Humidity

The relative humidity model uses a triangular distribution to simulate the daily average relative humidity from the monthly average. As with temperature and radiation, the mean daily relative humidity is adjusted to account for wet- and dry-day effects.

v. Snow

SWAT classifies precipitation as rain or freezing rain/snow using the average daily temperature.

SNOW COVER

The snow cover component of SWAT has been updated from a simple, uniform snow cover model to a more complex model which allows non-uniform cover due to shading, drifting, topography and land cover. The user defines a threshold snow depth above which snow cover will always equal 100% of the area. As the snow depth in a sub-basin decreases below this value, the snow coverage is allowed to decline non-linearly based on an area depletion curve.

SNOW MELT

The SWAT snow melt component is similar to that of the CREAMS model (Knisel, 1980). If snow is present, it is melted on days when the maximum temperature exceeds

0°C using a linear function of radiation, maximum/minimum air temperature, wind speed and dew point temperature. Melted snow is treated the same as rainfall for estimating runoff and percolation. For snow melt, rainfall energy is set to zero and the peak runoff rate is estimated assuming uniformly distributed rainfall for a 24 hour duration.

F. Elevation Bands

The model allows the sub-basin to be split into a maximum of ten elevation bands. Snow cover and snow melt are simulated separately for each elevation band. By dividing the sub-basin into elevation bands, the model is able to assess the differences in snow cover and snow melt caused by orographic variation in precipitation and temperature.

G. Soil Temperature

Soil temperature impacts water movement and the decay rate of residue in the soil. Daily average soil temperature is simulated at the soil surface and the centre of each soil layer. The temperature of the soil surface is a function of maximum and minimum air temperature, snow cover, plant cover and residue cover for the day being simulated and the preceding four days. The temperature of the soil layers is a function of the surface temperature, mean annual air temperature and the depth in the soil at which variation in temperature due to changes in climatic conditions no longer occurs. This depth, referred to as the damping depth, is dependent upon the bulk density and the soil water content.

H. Hydrology

As precipitation descends, it may be intercepted and held in the vegetation canopy or fall to the soil surface. Water on the soil surface will infiltrate into the soil profile or flow overland as runoff. Runoff moves relatively quickly toward a stream channel and contributes to short-term stream response. Infiltrated water may be held in the soil and later evapo-transpired or it may slowly make its way to the surface-water system via underground paths. The potential pathways of water movement simulated by SWAT in the HRU are illustrated in Figure 5.

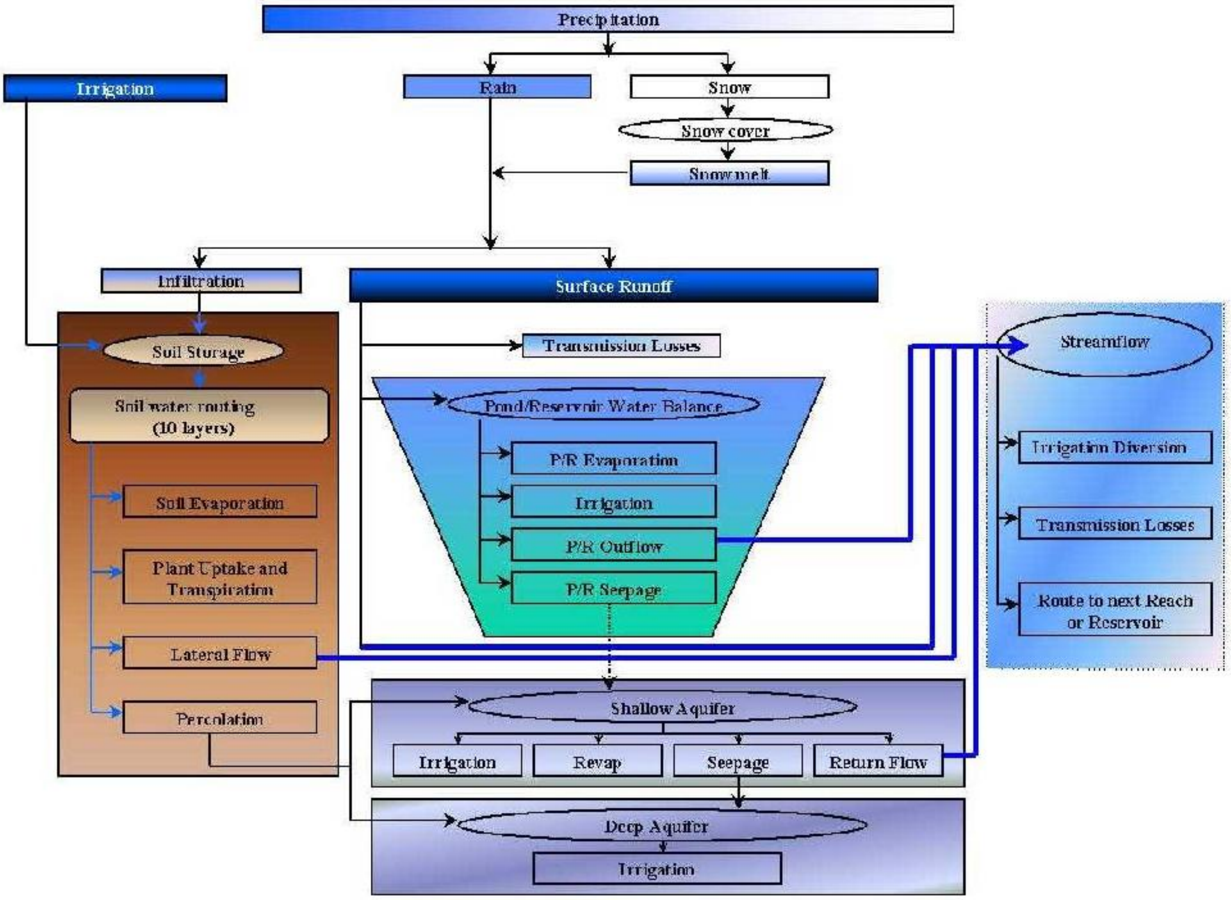
I. Canopy Storage

Canopy storage is the water intercepted by vegetative surfaces (the canopy) where it is held and made available for evaporation. When using the curve number method to compute surface runoff, canopy storage is taken into account in the surface runoff calculations. However, if methods such as Green & Ampt are used to model infiltration and runoff, canopy storage must be modelled separately. SWAT allows the user to input the maximum amount of water which can be stored in the canopy at the maximum leaf area index for the land cover. This value and the leaf area index are used by the model to compute the maximum storage at any time in the growth cycle of the land cover/crop. When evaporation is computed, water is first removed from canopy storage.

J. Infiltration

Infiltration refers to the entry of water into a soil profile from the soil surface. As infiltration continues, the soil becomes increasingly wet, causing the rate of infiltration to decrease with time until it reaches a steady value. The initial rate of infiltration depends on the moisture content of the soil prior to the introduction of water at the soil surface. The final rate of infiltration is equivalent to the saturated hydraulic conductivity of the soil. Because SWAT operates on a daily time-step, it is unable to directly model infiltration. The amount of water entering the soil profile is calculated as the difference between the amount of rainfall and the amount of surface runoff. The Green & Ampt infiltration model is currently being incorporated into SWAT and should be available for use before the end of the year.

Figure 5 Schematic of Pathways available for Water Movement in SWAT



K. Redistribution

Redistribution refers to the continued movement of water through a soil profile after input of water (via precipitation or irrigation) has ceased at the soil surface. Redistribution is caused by differences in water content in the profile. Once the water content throughout the entire profile is uniform, redistribution will cease.

The redistribution component of SWAT uses a storage routing technique to predict flow through each soil layer in the root zone. Downward flow, or percolation, occurs when field capacity of a soil layer is exceeded and the layer below is not saturated. The flow rate is governed by the saturated conductivity of the soil layer. Movement of water from a subsurface layer to an adjoining upper layer may occur when the water content of the lower layer exceeds field capacity. The upward movement of water is regulated by the soil water to field capacity ratios of the two layers. Redistribution is also affected by soil temperature. If the temperature in a particular layer is 0°C or below, no redistribution is allowed from that layer.

L. Evapotranspiration

Evapotranspiration is a collective term for all processes by which water in the liquid or solid phase at or near the earth's surface becomes atmospheric water vapour. Evapotranspiration includes evaporation from rivers and lakes, bare soil, and vegetative surfaces; evaporation from within the leaves of plants (transpiration); and sublimation from ice and snow surfaces. The model computes evaporation from soils and plants separately as described by Ritchie (1972). Potential soil water evaporation is estimated as a function of potential evapotranspiration and leaf area index (area of plant leaves relative to the area of the HRU). Actual soil water evaporation is estimated by using exponential functions of soil depth and water content. Plant transpiration is simulated as a linear function of potential evapotranspiration and leaf area index.

M. Potential Evapotranspiration

Potential evapotranspiration is the rate at which evapotranspiration would occur from a large area completely and uniformly covered with growing vegetation which has access to an unlimited supply of soil water. This rate is assumed to be unaffected by micro-climatic processes such as advection or heat-storage effects. The model offers three options for estimating potential evapotranspiration: Hargreaves (Hargreaves and Samani, 1985), Priestley-Taylor (Priestley and Taylor, 1972), and Penman-Monteith (Monteith, 1965).

N. Lateral Subsurface Flow

Lateral subsurface flow, or interflow, is streamflow contribution which originates below the surface but above the zone where rocks are saturated with water. Lateral subsurface flow in the soil profile (0 - 2m) is calculated simultaneously with redistribution. A kinematic storage model is used to predict lateral flow in each soil layer. The model accounts for variation in conductivity, slope and soil water content. It also allows for flow upward to an adjacent layer or to the surface.

O. Surface Runoff

Surface runoff, or overland flow, is flow that occurs along a sloping surface. Using daily rainfall amounts, SWAT simulates surface runoff volumes and peak runoff rates for each HRU.

Surface runoff volume is computed using a modification of the SCS curve number method (USDA Soil Conservation Service, 1972). The curve number varies non-linearly with the moisture content of the soil. The curve number drops as the soil approaches the wilting point and increases to near 100 as the soil approaches saturation. SWAT includes a provision for estimating runoff from frozen soil where a soil is defined as frozen if the temperature in the second soil layer is less than 0°C. The model increases runoff for frozen soils but still allows significant infiltration when the frozen soils are dry.

Peak runoff rate predictions are made with a modification of the rational method. In brief, the rational method is based on the idea that if a rainfall of intensity *i* begins instantaneously and continues indefinitely, the rate of runoff will increase until the time of concentration, t_c, when all of the sub-basin is contributing to flow at the outlet. In the modified Rational Formula, the peak runoff rate is a function of the proportion of daily precipitation that falls during the sub-basin t_c, the daily surface runoff volume, and the sub-basin time of concentration. The proportion of rainfall occurring during the sub-basin t_c is estimated as a function of total daily rainfall using a stochastic technique. The sub-basin time of concentration is estimated using Manning's Formula considering both overland and channel flow.

P. Ponds

Ponds are water storage structures located within a sub-basin, which intercept surface runoff. The catchment area of a pond is defined as a fraction of the total area of the sub-basin. When the catchment area fraction is equal to 1.00, the pond is assumed to be located at the outlet of the sub-basin on the main channel. If the catchment area fraction is less than 1.00, the pond is assumed to be located on a minor tributary within the sub-basin. Pond water storage is a function of pond capacity, daily inflows and outflows, seepage and evaporation. Ponds are assumed to have only emergency spillways. Required inputs are the storage capacity and surface area of the pond when filled to capacity. Surface area below capacity is estimated as a non-linear function of storage.

Q. Tributary Channels

Two types of channels are defined within a sub-basin: the main channel and tributary channels. Tributary channels are minor or lower order channels branching off the main channel within the sub-basin. Each tributary channel within a sub-basin drains only a portion of the sub-basin and does not receive groundwater contribution to its flow. All flow in the tributary channels is released and routed through the main channel of the sub-basin. SWAT uses the attributes of tributary channels to determine the time of concentration for the sub-basin.

R. Transmission Losses

Transmission losses are losses of surface flow via leaching through the streambed. This type of loss occurs in ephemeral or intermittent streams where groundwater contribution occurs only at certain times of the year, or not at all. SWAT uses Lane's method described in Chapter 19 of the SCS Hydrology Handbook (USDA Soil Conservation Service, 1983) to estimate transmission losses. Water losses from the channel are a function of channel width and length and flow duration. Both runoff volume and peak rate are adjusted when transmission losses occur in tributary channels.

S. Return Flow

Return flow, or base flow, is the volume of streamflow originating from groundwater. SWAT partitions groundwater into two aquifer systems: a shallow, unconfined aquifer which contributes return flow to streams within the watershed and a deep, confined aquifer which contributes return flow to streams outside the watershed (Arnold et al., 1993). Water percolating past the bottom of the root zone is partitioned into two fractions—each fraction becomes recharge for one of the aquifers. In addition to return flow, water stored in the shallow aquifer may replenish moisture in the soil profile in very dry conditions or be directly removed by plant uptake (only trees may uptake water from the shallow aquifer). Water in the shallow aquifer may also seep into the deep aquifer or be removed by pumping. Water in the deep aquifer may be removed by pumping.

T. Land Cover/Plant Growth

SWAT utilizes a single plant growth model to simulate all types of land covers. The model is able to differentiate between annual and perennial plants. Annual plants grow from the planting date to the harvest date or until the accumulated heat units equal the potential heat units for the plant. Perennial plants maintain their root systems throughout the year, becoming dormant after frost. They resume growth when the average daily air temperature exceeds the minimum, or base, temperature required. The plant growth model is used to assess removal of water and nutrients from the root zone, transpiration, and biomass/yield production.

i. Potential Growth

The potential increase in plant biomass on a given day is defined as the increase in biomass under ideal growing conditions. The potential increase in biomass for a day is a function of intercepted energy and the plant's efficiency in converting energy to biomass. Energy interception is estimated as a function of solar radiation and the plant’s leaf area index.

ii. Potential and Actual Transpiration

The process used to calculate potential plant transpiration is described the section on evapotranspiration. Actual transpiration is a function of potential transpiration and the soil water content.

iii. Nutrient Uptake

Plant use of nitrogen and phosphorus are estimated with a supply and demand approach where the daily plant nitrogen and phosphorus demands are calculated as the difference between the actual concentration of the element in the plant and the optimal concentration. The optimal concentration of the elements varies with growth stage as described by Jones (1983).

iv. Growth Constraints

Potential plant growth and yield are usually not achieved due to constraints imposed by the environment. The model estimates stresses caused by water, nutrients and temperature.

U. Erosion

Erosion and sediment yield are estimated for each HRU with the Modified Universal Soil Loss Equation (MUSLE) (Williams, 1975). While the USLE uses rainfall as an indicator of erosive energy, MUSLE uses the amount of runoff to simulate erosion and sediment yield. The substitution results in a number of benefits: the prediction accuracy of the model is increased, the need for a delivery ratio is eliminated, and single storm estimates of sediment yields can be calculated. The hydrology model supplies estimates of runoff volume and peak runoff rate which, with the sub-basin area, are used to calculate the runoff erosive energy variable. The crop management factor is recalculated every day that runoff occurs. It is a function of above-ground biomass, residue on the soil surface, and the minimum C factor for the plant. Other factors of the erosion equation are evaluated as described by Wischmeier and Smith (1978).

V. Management

SWAT allows the user to define management practices taking place in every HRU. The user may define the beginning and the ending of the growing season, specify timing and amounts of fertilizer, pesticide and irrigation applications as well as timing of tillage operations. At the end of the growing season, the biomass may be removed from the HRU as yield or placed on the surface as residue.

In addition to these basic management practices, operations such as grazing, automated fertilizer and water applications, and incorporation of every conceivable management option for water use are available. The latest improvement to land management is the incorporation of routines to calculate sediment and nutrient loadings from urban areas.

i. Rotations

The dictionary defines a rotation as the growing of different crops in succession in one field, usually in a regular sequence. A rotation in SWAT refers to a change in management practices from one year to the next. There is no limit to the number of years of different management operations specified in a rotation. SWAT also does not limit the number of land cover/crops grown within one year in the HRU. However, only one land cover can be growing at any one time.

ii. Water Use

The two most typical uses of water are for application to agricultural lands or use as a town's water supply. SWAT allows water to be applied on an HRU from any water source within or outside the watershed. Water may also be transferred between reservoirs, reaches and sub-basins as well as exported from the watershed.

W. Routing Phase of the Hydrologic Cycle

Once SWAT determines the loadings of water, sediment, nutrients and pesticides to the main channel, the loadings are routed through the stream network of the watershed using a command structure similar to that of HYMO (Williams and Hann, 1972). In addition to keeping track of mass flow in the channel, SWAT models the transformation of chemicals in the stream and streambed. Figure 6 illustrates the different in-stream processes modelled by SWAT.

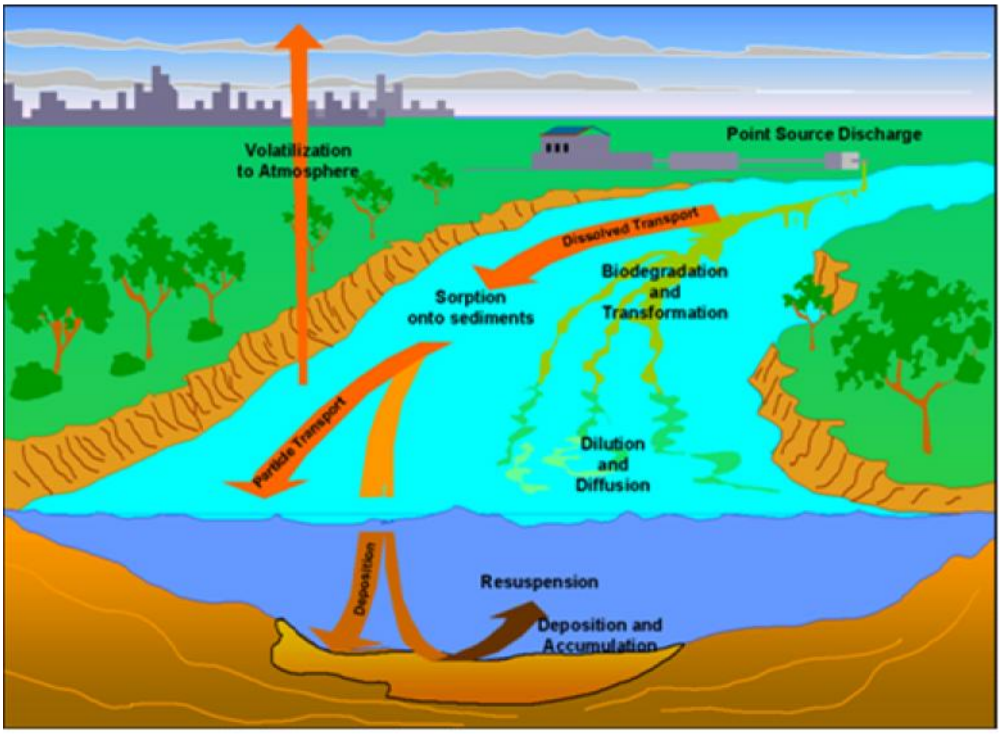
i. Routing in the Main Channel or Reach

Routing in the main channel can be divided into four components: water, sediment, nutrients and organic chemicals.

ii. Flood Routing

As water flows downstream, a portion may be lost due to evaporation and transmission through the bed of the channel. Another potential loss is removal of water from the channel for agricultural or human use. Flow may be supplemented by the fall of rain directly on the channel and/or addition of water from point source discharges. Flow is routed through the channel using a variable storage coefficient method developed by Williams (1969).

Figure 6: In-stream Processes Modelled by SWAT



iii. Sediment Routing

The transport of sediment in the channel is controlled by the simultaneous operation of two processes, deposition and degradation. Deposition in the channel is based on sediment particle fall velocity calculated with Stoke's Law. Stream power is used to predict degradation in the routing reaches. Bagnold (1977) defined stream power as the product of water density, flow rate and water surface slope. Williams (1980) modified Bagnold's equation to place more weight on high values of stream power—stream power raised to 1.5. Prior to incorporation into SWAT, the stream power equation was further simplified to make stream power no longer a function of water surface slope. Available stream power is used to re-entrain loose and deposited material until all of the material is removed. Excess stream power causes bed degradation. Bed degradation is adjusted for stream bed erodibility and cover.

iv. Routing in the Reservoir

The water balance for reservoirs includes inflow, outflow, rainfall on the surface, evaporation, seepage from the reservoir bottom and diversions.

Reservoir Outflow

The model offers three alternatives for estimating outflow from the reservoir. The first option allows the user to input measured outflow. The second option, designed for small, uncontrolled reservoirs, requires the users to specify a water release rate. When the reservoir volume exceeds the principle storage, the extra water is released at the specified rate. Volume exceeding the emergency spillway is released within one day. The third option, designed for larger, managed reservoirs, has the user specify monthly target volumes for the reservoir.

Sediment Routing

Sediment inflow may originate from transport through the upstream reaches or from surface runoff within the sub-basin. The concentration of sediment in the reservoir is estimated using a simple continuity equation based on volume and concentration of inflow, outflow, and water retained in the reservoir. Settling of sediment in the reservoir is governed by Stoke's Law. The amount of sediment in the reservoir outflow is the product of the volume of water flowing out of the reservoir and the suspended sediment concentration in the reservoir at the time of release.

X. References

Arnold, J.G., P.M. Allen, and G. Bernhardt. 1993. A comprehensive surface-groundwater flow model. J. Hydrol. 142:47-69.

Arnold, J.G., J.R. Williams, A.D. Nicks, and N.B. Sammons. 1990. SWRRB: A basin scale simulation model for soil and water resources management. Texas A&M Univ. Press, College Station, TX.

Arnold, J.G., J.R. Williams and D.R. Maidment. 1995. Continuous-time water and sediment-routing model for large basins. Journal of Hydraulic Engineering 121(2):171-183.

Bagnold, R.A. 1977. Bedload transport in natural rivers. Water Resources Res. 13(2):303-312.

Brown, L.C. and T.O. Barnwell, Jr. 1987. The enhanced water quality models QUAL2E and QUAL2E-UNCAS documentation and user manual. EPA document EPA/600/3-87/007. USEPA, Athens, GA.

Chapra, S.C. 1989. Water quality modelling of toxic organics in lakes. CADSWES Working Paper No. 4. Univ. Colorado, Boulder, CO.

Hargreaves, G.H. and Z.A. Samani. 1985. Reference crop evapotranspiration from temperature. Applied Engineering in Agriculture 1:96-99.

Jones, C.A. 1983. A survey of the variability in tissue nitrogen and phosphorus concentrations in maize and grain sorghum. Field Crops Res. 6:133-147.

Knisel, W.G. 1980. CREAMS, a field scale model for chemicals, runoff and erosion from agricultural management systems. USDA Conservation Research Rept. No. 26.

Leonard, R.A. and R.D. Wauchope. 1980. Chapter 5: The pesticide submodel. p. 88-112. *In* Knisel, W.G. (ed). CREAMS: A field-scale model for chemicals, runoff, and erosion from agricultural management systems. U.S. Department of Agriculture, Conservation research report no. 26.

Leonard, R.A., W.G. Knisel, and D.A. Still. 1987. GLEAMS: Groundwater loading effects on agricultural management systems. Trans. ASAE 30(5):1403-1428.

McElroy, A.D., S.Y. Chiu, J.W. Nebgen, and others. 1976. Loading functions for assessment of water pollution from nonpoint sources. EPA document EPA 600/2-76-151. USEPA, Athens, GA.

Monteith, J.L. 1965. Evaporation and the environment. p. 205-234. *In* The state and movement of water in living organisms. 19th Symposia of the Society for Experimental Biology. Cambridge Univ. Press, London, U.K.

Nicks, A.D. 1974. Stochastic generation of the occurrence, pattern and location of maximum amount of daily rainfall. p. 154-171. *In* Proc. Symp. Statistical

Hydrology, Tucson, AZ. Aug.-Sept. 1971. USDA Misc. Publ. 1275. U.S. Gov. Print. Office, Washington, DC.

Priestley, C.H.B. and R.J. Taylor. 1972. On the assessment of surface heat flux and evaporation using large-scale parameters. Mon. Weather Rev. 100:81-92.

Richardson, C.W. and D.A. Wright. 1984. WGEN: A model for generating daily weather variables. USDA Agricultural Research Service, ARS-8.

Ritchie, J.T. 1972. A model for predicting evaporation from a row crop with incomplete cover. Water Resour. Res. 8:1204-1213.

Thormann, R.V. and J.A. Mueller. 1987. Principles of surface water quality modeling and control. Harper & Row, Inc., New York, NY.

USDA Soil Conservation Service. 1983. National Engineering Handbook Section 4 Hydrology, Chapter 19.

USDA Soil Conservation Service. 1972. National Engineering Handbook Section 4 Hydrology, Chapters 4-10.

Williams, J.R. 1980. SPNM, a model for predicting sediment, phosphorus, and nitrogen yields from agricultural basins. Water Resour. Bull. 16(5):843-848.

Williams, J.R. 1975. Sediment routing for agricultural watersheds. Water Resour. Bull. 11(5):965-974.

Williams, J.R. 1969. Flood routing with variable travel time or variable storage coefficients. Trans. ASAE 12(1):100-103.

Williams, J.R., A.D. Nicks, and J.G. Arnold. 1985. Simulator for water resources in rural basins. Journal of Hydraulic Engineering 111(6): 970-986.

Williams, J.R. and R.W. Hann. 1978. Optimal operation of large agricultural watersheds with water quality constraints. Texas Water Resources Institute, Texas A&M Univ., Tech. Rept. No. 96.

Williams, J.R. and R.W. Hann. 1972. HYMO, a problem-oriented computer language for building hydrologic models. Water Resour. Res. 8(1):79-85.

Williams, J.R., C.A. Jones and P.T. Dyke. 1984. A modeling approach to determining the relationship between erosion and soil productivity. Trans. ASAE 27(1):129-144.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall losses: A guide to conservation planning. USDA Agricultural Handbook No. 537. U.S. Gov. Print. Office, Washington, D. C.

Appendix 3

Rainfall Stations after Validation

New basin boundaries have been finalised using 90 m SRTM. As per the new basin boundaries, information regarding number of rain gauge stations falling in each basin, which have been validated, is given below. The stations mentioned in this document are the 327 which are used for model simulation in this Study.

Table 1 Number of Raingauges within Various Basins as per New Modified Basin Boundaries

Basin Name	Total No. of Rain Gauges
Banas	92
Banganga	20
Chambal	41
Gambhir	10
Ghaggar	6
Luni	44
Mahi	36
Other Nallahs of Jalore	0
Outside Basin	34
Parbati	4
Ruparail	6
Sabarmati	3
Sabi	9
Shekhawati	12
Sukli	1
West Banas	9

Table 2 List of Screened Rainfall Stations after Validation

WRIS code	Station Name	Latitude	Longitude	Basin Name
196	Moran Sagar *	26°39’48"	76°32’20"	Banas
192	Bamanwas	26°33’27"	76°33’40"	Banas
252	Bansur	27°40’60"	76°20’60"	Sabi
204	Talabshahi *	26°37’60"	77°40’60"	Parbati
200	Bari	26°38’60"	77°35’60"	Parbati
202	Sepau	26°49’00"	77°39’00"	Gambhir
233	Baseri	26°45’00"	77°31’60"	Gambhir
199	Angai *	26°36’00"	77°27’00"	Parbati
203	Sirmathura	26°31’31"	77°21’39"	Parbati

WRIS code	Station Name	Latitude	Longitude	Basin Name
382	Sadri *	25°07’00"	73°28’00"	Luni
380	Muthana *	25°13’60"	73°28’00"	Luni
379	Kana *	25°15’49"	73°30’46"	Luni
374	Desuri	25°16’14"	73°35’24"	Luni
348	Jaitaran	26°11’60"	73°57’00"	Luni
543	Jalore	25°30’00"	72°37’00"	Luni
391	Ahore	25°23’00"	72°46’00"	Luni
413	Jaswantpura	24°48’00"	72°28’00"	Luni
365	Jograwas *	25°46’07"	73°34’60"	Luni

WRIS code	Station Name	Latitude	Longitude	Basin Name
230	Baretha *	26°53’60"	77°22’00"	Gambhir
231	Bayana	26°53’60"	77°16’60"	Gambhir
258	Sodawas *	27°51’41"	76°24’17"	Sabi
253	Behror	27°52’60"	76°16’60"	Shekhawati
193	Bonli	26°19’45"	76°13’37"	Banas
406	Morel Dam *	26°26’48"	76°19’55"	Banas
209	Deeg	27°26’60"	77°19’00"	Banganga
9	Urmila Sagar *	26°38’01"	77°49’55"	Chambal
673	Dholpur (a)	26°41’60"	77°54’00"	Chambal
8	Dholpur	26°41’60"	77°54’00"	Chambal
194	Gangapur City	26°28’43"	76°43’43"	Banas
236	Juggar *	26°43’00"	77°05’60"	Gambhir
235	Hindaun	26°43’00"	77°00’60"	Gambhir
212	Kaman	27°38’60"	77°15’60"	Banganga
238	Karauli	26°30’00"	77°00’60"	Gambhir
245	Kathumbar	27°19’60"	77°04’00"	Banganga
158	Kishangarh	27°49’00"	76°43’00"	Banganga
254	Kishangarh Bas	27°49’00"	76°43’00"	Banganga
255	Kotkasim	28°01’60"	76°43’00"	Sabi
217	Sewar *	27°15’00"	77°20’00"	Banganga
213	Kumher	27°19’00"	77°22’00"	Banganga
244	Govindgarh	27°30’00"	77°00’00"	Ruparail
228	Mahuwa	27°03’00"	76°54’60"	Banganga
256	Mandawar	27°52’00"	76°32’60"	Sabi
214	Nadbai	27°13’00"	77°10’60"	Banganga
219	Weir	27°10’60"	77°10’60"	Banganga
241	Nadoti	26°43’00"	76°43’60"	Gambhir
257	Neemrana	28°00’00"	76°22’60"	Shekhawati
215	Nagar	27°25’00"	77°05’60"	Banganga
541	Pahari	27°42’38"	77°05’05"	Banganga
249	Rajgarh	27°13’00"	76°37’00"	Ruparail
248	Ramgarh	27°34’60"	76°49’00"	Ruparail
234	Rupwas	26°58’60"	77°34’00"	Gambhir
197	Kalisil *	26°15’48"	76°44’36"	Banas
198	Sapotra	26°17’30"	76°45’09"	Banas
206	Ajan *	27°09’57"	77°28’30"	Banganga
208	Bharatpur	27°14’11"	77°27’51"	Banganga
251	Thanagazi	27°25’00"	76°17’60"	Sabi
260	Tijara	27°56’60"	76°50’60"	Sabi

WRIS code	Station Name	Latitude	Longitude	Basin Name
371	Hemawas *	25°44’08"	73°22’58"	Luni
363	Baniawas *	25°46’00"	73°31’00"	Luni
372	Pali	25°46’13"	73°19’42"	Luni
360	Raipur Luni *	26°03’00"	74°01’60"	Luni
341	Girinanda *	26°10’60"	74°10’60"	Luni
359	Raipur	26°03’00"	74°01’60"	Luni
548	Reodhar *	24°37’00"	72°31’60"	Sukli
375	Kharda *	25°55’00"	73°14’00"	Luni
547	Sheoganj *	25°08’22"	73°04’04"	Luni
410	Ora *	25°01’00"	72°47’60"	Luni
411	Sirohi	24°52’60"	72°52’00"	Luni
409	Danta *	24°48’00"	72°50’60"	West Banas
349	Meli Tank *	25°45’00"	72°28’00"	Luni
351	Siwana	25°38’60"	72°24’60"	Luni
361	Sardar Samand *	25°58’56"	73°22’58"	Luni
362	Sojat	25°55’56"	73°39’18"	Luni
389	Takhatgarh *	25°19’00"	73°01’00"	Luni
388	Sanderao *	25°20’18"	73°11’11"	Luni
350	Pachpadra	25°55’60"	72°16’00"	Luni
354	Balotra	25°49’60"	72°15’00"	Luni
438	Barmer (a)	25°45’23"	71°24’03"	Luni
439	Barmer	25°45’23"	71°24’03"	Luni
520	Jodhpur *	26°18’00"	73°01’00"	Luni
518	Jodhpur	26°18’00"	73°01’60"	Luni
536	Osian	26°43’00"	72°55’00"	Luni
523	Phalodi (a)	27°07’60"	72°22’00"	Outside Basin
524	Phalodi	27°07’60"	72°22’00"	Outside Basin
443	Sheo	26°10’60"	71°15’00"	Luni
185	Jaipur (a)	26°48’55"	75°46’60"	Banas
184	Jaipur	26°54’49"	75°47’04"	Banas
190	Sanganer	26°48’55"	75°46’60"	Banas
426	Chomu	27°10’00"	75°39’60"	Shekhawati
180	Amber	26°58’60"	75°52’00"	Banas
154	Arain	26°26’59"	75°02’44"	Banas
160	Sarwar	26°03’54"	75°01’14"	Banas
220	Baswa	27°08’60"	76°35’00"	Banganga
181	Bassi	26°50’07"	76°03’04"	Banas
155	Bhinai	26°03’06"	74°46’18"	Banas
157	Goela	26°07’18"	74°56’51"	Banas

WRIS code	Station Name	Latitude	Longitude	Basin Name
259	Tapukra	28°07’00"	76°49’00"	Sabi
229	Toda Bhim	26°55’00"	76°49’00"	Gambhir
250	Siliserh *	27°31’00"	76°31’60"	Ruparail
243	Alwar	27°34’00"	76°35’60"	Ruparail
247	Malakhera	27°23’29"	76°37’30"	Ruparail
211	Hingota *	27°05’29"	77°02’16"	Banganga
210	Halena *	27°07’00"	77°07’00"	Banganga
444	Bikaner (a)	28°00’00"	73°17’60"	Outside Basin
445	Bikaner	28°01’00"	73°17’60"	Outside Basin
510	Jaisalmer (a)	26°53’60"	70°55’00"	Outside Basin
511	Jaisalmer	26°53’60"	70°55’00"	Outside Basin
447	Kolayat	27°49’22"	72°57’45"	Outside Basin
446	Lunkaransar	28°30’00"	73°45’00"	Outside Basin
449	Nokha	27°32’42"	73°28’54"	Outside Basin
526	Surpura *	27°42’32"	73°26’52"	Outside Basin
456	Sujangarh	27°41’60"	74°28’60"	Outside Basin
64	Mangrol	25°20’01"	76°30’56"	Chambal
59	Atru	24°52’01"	76°39’56"	Chambal
32	Bakani	24°18’02"	76°13’56"	Chambal
60	Baran	25°06’09"	76°29’29"	Chambal
49	Gudha Dam *	25°06’09"	76°29’29"	Chambal
61	Chhabra	24°40’01"	76°50’56"	Chambal
33	Bhimsagar *	24°36’01"	76°31’56"	Chambal
62	Chhipabarod	24°37’01"	76°46’56"	Chambal
25	Gangdhar	23°56’02"	75°35’56"	Chambal
34	Dug	23°56’02"	75°49’56"	Chambal
162	Chandsen *	25°21’01"	75°19’56"	Chambal
48	Bundi	25°27’01"	75°37’56"	Chambal
50	Hindoli	25°35’01"	75°29’56"	Chambal
65	Pipalda	25°34’01"	76°26’56"	Chambal
36	Jhalawar	24°32’02"	76°09’56"	Chambal
37	Jhalrapatan	24°33’02"	76°08’56"	Chambal
31	Asnawar	24°29’02"	76°20’56"	Chambal
40	Pachpahar	24°24’02"	75°49’56"	Chambal
45	Ramganjmandi	24°38’01"	75°55’56"	Chambal
120	Khandar	26°01’00"	76°37’00"	Banas
21	Mansarowar *	25°59’01"	76°29’56"	Chambal
38	Khanpur	24°44’01"	76°22’56"	Chambal

WRIS code	Station Name	Latitude	Longitude	Basin Name
182	Chaksu	26°36’21"	75°56’44"	Banas
221	Dausa	26°53’60"	76°20’00"	Banganga
127	Moti Sagar *	25°55’00"	75°39’60"	Banas
130	Panwar Sagar *	25°45’00"	75°30’00"	Banas
128	Nasirda *	25°56’41"	75°22’05"	Banas
165	Chhaparwara *	26°37’39"	75°15’53"	Banas
427	Phulera	26°52’60"	75°13’60"	Shekhawati
171	Naraina	26°47’30"	75°12’19"	Banas
222	Jamwa Ramgarh	27°02’43"	76°03’34"	Banganga
343	Beawar *	26°06’00"	74°19’00"	Luni
186	Kanota *	26°52’33"	75°56’34"	Banas
135	Kekri	25°58’00"	75°09’00"	Banas
262	Kotputli	27°43’00"	76°13’00"	Sabi
188	Rahuwas *	26°41’59"	76°20’08"	Banas
187	Lalsot	26°33’39"	76°19’31"	Banas
164	Tordi Sagar*	26°12’32"	75°25’07"	Banas
175	Malpura	26°17’44"	75°22’34"	Banas
163	Lamba Hari Singh *	26°18’17"	75°09’42"	Banas
136	Masuda	26°07’00"	74°31’60"	Banas
179	Niwai	26°21’48"	75°55’38"	Banas
176	Mashi *	26°22’60"	75°45’60"	Banas
159	Nasira Bad	26°17’49"	74°44’12"	Banas
423	Ajmer (a)	26°28’31"	74°39’13"	Luni
424	Ajmer	26°28’31"	74°39’13"	Luni
346	Pushkar	26°28’60"	74°32’60"	Luni
345	Pisangan	26°23’60"	74°30’00"	Luni
344	Mangliawas	26°16’60"	74°30’00"	Luni
173	Phagi	26°34’40"	75°33’36"	Banas
428	Sambhar	26°55’00"	75°09’60"	Shekhawati
161	Sri Nagar	26°26’05"	74°46’31"	Banas
156	Gegal	26°31’60"	74°45’00"	Shekhawati
226	Sikrai	26°55’00"	76°42’00"	Banganga
131	Toda Rai Singh	26°01’60"	75°28’60"	Banas
133	Tonk *	26°10’00"	75°47’60"	Banas
132	Tonk	26°10’00"	75°47’60"	Banas
177	Pipalu	26°17’46"	75°43’05"	Banas
577	Galwar *	25°52’01"	76°10’56"	Chambal
58	Galvania Bund *	25°52’01"	76°10’56"	Chambal

WRIS code	Station Name	Latitude	Longitude	Basin Name
66	Ummed Sagar *	25°13’01"	76°46’56"	Chambal
63	Kishanganj	25°06’01"	76°38’56"	Chambal
17	Kota Barrage *	25°11’01"	75°49’56"	Chambal
15	Kota A.p. (a)	25°11’01"	75°50’56"	Chambal
26	Aklera	24°25’02"	76°33’56"	Chambal
51	Nainwa	25°48’01"	75°51’56"	Chambal
39	Pirawa	24°09’39"	76°01’41"	Chambal
46	Sangod	24°56’01"	76°16’56"	Chambal
178	Dheel *	26°13’24"	76°07’03"	Banas
122	Sawai Madhopur	26°01’22"	76°21’15"	Banas
12	Digod	25°13’01"	76°04’56"	Chambal
19	Ladpura	25°08’01"	75°41’56"	Chambal
52	Talera	25°20’01"	75°42’56"	Chambal
435	Chirawa	28°13’60"	75°39’00"	Outside Basin
450	Churu (a)	28°18’00"	74°58’00"	Outside Basin
451	Churu	28°18’00"	74°58’00"	Outside Basin
433	Ramgarh Shethan	27°13’60"	75°12’00"	Shekhawati
432	Dantaramgarh	27°15’00"	75°12’00"	Shekhawati
339	Degana	26°53’60"	74°19’00"	Luni
532	Fatehpur	27°58’60"	74°58’00"	Outside Basin
436	Jhunjhunu	28°07’60"	75°22’60"	Outside Basin
420	Khetri	28°00’03"	75°47’17"	Shekhawati
430	Nawa	27°01’00"	75°00’60"	Shekhawati
533	Laxmangarh	27°49’60"	75°01’60"	Outside Basin
529	Ladnu	27°38’60"	74°22’60"	Outside Basin
421	Neem Ka Thana	27°43’60"	75°46’60"	Shekhawati
431	Parbatsar	26°52’00"	74°45’60"	Shekhawati
534	Sikar *	27°37’00"	75°07’60"	Outside Basin
535	Sikar	27°37’00"	75°07’60"	Outside Basin
437	Pilani (a)	28°21’00"	75°35’60"	Outside Basin
422	Udaipur Wati	27°43’22"	75°28’08"	Outside Basin
3	Arnod	23°53’00"	74°45’00"	Mahi
290	Aspur	23°56’60"	74°05’00"	Mahi
297	Sabla	23°51’00"	74°12’00"	Mahi
296	Nithawa	23°55’00"	74°17’60"	Mahi
314	Shergarh	23°19’60"	74°10’00"	Mahi
310	Bagidora	23°25’00"	74°17’60"	Mahi
265	Banswara (a)	23°33’37"	74°26’31"	Mahi

WRIS code	Station Name	Latitude	Longitude	Basin Name
263	Paota	27°34’60"	76°05’00"	Sabi
331	Mount Abu (a)	24°36’01"	72°43’04"	West Banas
332	Mount Abu	24°36’01"	72°43’04"	West Banas
325	Abu Road	24°28’60"	72°47’60"	West Banas
73	Amet	25°18’30"	73°54’54"	Banas
148	Patan *	25°54’35"	74°22’08"	Banas
116	Sawar	25°45’00"	74°13’00"	Banas
141	Asind	25°43’60"	74°19’00"	Banas
142	Badnore	25°50’19"	74°16’56"	Banas
143	Banera	25°31’00"	74°40’00"	Banas
86	Badi Sadri	24°26’60"	74°28’60"	Banas
5	Begun	24°59’01"	75°07’57"	Chambal
98	Sandesar *	24°40’00"	74°20’00"	Banas
85	Bhadesar	24°41’60"	74°28’60"	Banas
4	Bhainsrorgarh	24°58’01"	75°31’56"	Chambal
152	Bhim	25°44’17"	74°04’45"	Banas
109	Vallabhnagar *	24°41’60"	74°00’00"	Banas
84	Badgaon *	24°42’26"	74°05’22"	Banas
108	Vallabhnagar	24°41’60"	74°00’00"	Banas
87	Bhopalsagar	24°51’10"	74°12’17"	Banas
280	Chhoti Sadri	24°23’60"	74°42’00"	Mahi
146	Khari Dam *	25°01’60"	74°49’60"	Banas
96	Orai *	25°01’60"	74°50’00"	Banas
89	Chittaurgarh	24°54’03"	74°37’24"	Banas
153	Deo Garh	25°31’44"	73°54’26"	Banas
90	Dungla	24°30’24"	74°19’50"	Banas
92	Gangrar	25°03’00"	74°35’60"	Banas
76	Gogunda	24°45’00"	73°34’00"	Banas
138	Vijaynagar	25°55’00"	74°39’60"	Banas
139	Agucha *	25°49’60"	74°42’00"	Banas
149	Sareri *	25°41’51"	74°34’51"	Banas
145	Hurda	25°55’00"	74°40’60"	Banas
117	Jahazpur	25°36’00"	75°16’60"	Banas
125	Deoli	25°45’00"	75°25’00"	Banas
137	Tatgarh	25°41’27"	73°58’11"	Banas
321	Jhadol	24°23’60"	73°29’00"	Sabarmati
94	Kapasan	24°52’60"	74°19’00"	Banas
78	Nathdwara	24°55’00"	73°50’00"	Banas

WRIS code	Station Name	Latitude	Longitude	Basin Name
266	Banswara	23°33’37"	74°26’31"	Mahi
294	Dungarpur	23°51’00"	73°43’00"	Mahi
323	Kanba	23°48’51"	73°34’09"	Mahi
292	Dewal	23°55’60"	73°42’00"	Mahi
268	Danpur	23°31’00"	74°43’60"	Mahi
288	Dhariawad	24°06’00"	74°26’58"	Mahi
295	Ganeshpur	23°55’00"	73°54’60"	Mahi
264	Arthuna	23°30’00"	74°05’00"	Mahi
269	Garhi	23°36’00"	74°07’60"	Mahi
273	Loharia	23°46’00"	74°13’60"	Mahi
270	Ghatol	23°46’00"	74°24’60"	Mahi
267	Bhungra	23°40’60"	74°30’60"	Mahi
271	Jagpura	23°52’00"	74°20’60"	Mahi
312	Kushalgarh	23°12’29"	74°26’04"	Mahi
274	Mahi Dam *	23°37’60"	74°33’07"	Mahi
275	Pipalkhunt	23°46’60"	74°35’00"	Mahi
309	Sagwara	23°41’00"	74°01’60"	Mahi
820	Sajjangarh	23°15’33"	74°17’23"	Mahi
305	Salumber	24°01’60"	74°12’00"	Mahi
308	Galiakot	23°33’00"	74°00’00"	Mahi
322	Dhambola	23°36’00"	73°46’00"	Sabarmati
484	Longwala *	29°33’29"	74°05’44"	Outside Basin
458	Anupgarh	29°11’07"	73°12’51"	Ghaggar
507	T.a. Singh *	29°11’41"	74°51’09"	Outside Basin
460	Bhadra	29°07’26"	75°10’00"	Outside Basin
470	Ganganagar (a)	29°55’00"	73°52’60"	Outside Basin
471	Ganganagar	29°55’00"	73°52’60"	Outside Basin
475	Hanumangarh	29°34’60"	74°19’00"	Ghaggar
481	Srikaranpur	29°50’53"	73°27’06"	Outside Basin
490	Padampur	29°42’10"	73°37’43"	Outside Basin
492	Pilibanga	29°26’60"	74°04’00"	Ghaggar
495	Raisinghnagar	29°31’60"	73°27’00"	Outside Basin
466	Dabla	29°27’55"	73°38’03"	Ghaggar
496	Sadulshahar	29°53’60"	74°10’00"	Outside Basin
467	Dhaban *	29°52’55"	74°30’53"	Outside Basin
497	Sangriya	29°47’52"	74°27’41"	Outside Basin
502	Suratgarh	29°19’00"	73°54’00"	Ghaggar
504	Sunderpura *	29°47’56"	74°05’14"	Outside Basin

WRIS code	Station Name	Latitude	Longitude	Basin Name
307	Som Ka Gadar *	24°01’47"	73°37’50"	Mahi
298	Babalwara *	24°05’44"	73°27’42"	Mahi
77	Kherwada	23°58’60"	73°35’60"	Mahi
315	Kotra	24°22’60"	73°10’60"	Sabarmati
69	Kotri	25°25’60"	74°52’60"	Banas
384	Kumbhalgarh	25°10’00"	73°34’00"	Luni
114	Meja Dam *	25°23’36"	74°32’25"	Banas
134	Jawaja	25°37’00"	74°13’00"	Banas
113	Mandal	25°25’60"	74°32’60"	Banas
68	Mandalgarh	25°12’34"	75°05’04"	Banas
53	Bijolia	25°11’10"	75°21’56"	Chambal
104	Udaipur Dabok (a)	24°37’28"	73°51’35"	Banas
99	Bagolia *	24°48’00"	73°50’00"	Banas
102	Maoli	24°49’00"	73°58’60"	Banas
93	Gambhiri *	24°41’60"	74°43’00"	Banas
95	Nimbahera	24°37’00"	74°42’00"	Banas
334	Sarupsagar *	24°52’00"	73°02’60"	West Banas
336	West Banas *	24°42’25"	72°56’07"	West Banas
328	Kadambari *	24°46’60"	73°05’00"	West Banas
390	Bhula *	24°34’34"	72°59’14"	West Banas
333	Pindwara	24°48’00"	73°04’00"	West Banas
6	Gadola *	24°10’00"	74°47’60"	Mahi
283	Pratap Garh	24°04’00"	74°46’60"	Chambal
651	Bharai *	24°58’60"	74°04’00"	Banas
80	Railmagra	25°01’60"	74°07’60"	Banas
81	Rajsamand	25°03’27"	73°53’55"	Banas
72	Rashmi	25°03’00"	74°22’00"	Banas
304	Rikhabdeo *	24°07’00"	73°43’00"	Mahi
70	Sahada	25°10’60"	74°13’60"	Banas
299	Jaisamand *	24°14’52"	73°57’18"	Mahi
306	Sarada	24°10’60"	73°54’60"	Mahi
140	Arwar Dam *	25°48’11"	74°48’52"	Banas
151	Ummed Sagar *	25°34’08"	74°54’28"	Banas
147	Nahar Sagar *	25°43’00"	74°57’00"	Banas
150	Shahpura	25°37’25"	74°55’32"	Banas
111	Bhilwara	25°19’40"	74°35’16"	Banas
313	Sallapat	23°10’48"	74°09’51"	Mahi
355	Bilara	26°10’60"	73°42’00"	Luni

WRIS code	Station Name	Latitude	Longitude	Basin Name
508	Tibbi	29°31’60"	74°30’00"	Ghaggar
561	Bali	25°10’60"	73°16’60"	Luni

WRIS code	Station Name	Latitude	Longitude	Basin Name
353	Jaswant Sagar *	26°13’28"	73°41’21"	Luni

* Maintained by WRD
(a) Maintained by IMD
Note: Other stations without suffix are maintained by Revenue Department

Appendix 4

Comparison of Various Methods of Estimating Missing Rainfall Data

1. Methods for Estimating Missing Data

In order to test the accuracy of methods used in estimation of missing data, a rain gauge station (X) and neighbouring stations, for which data is available for the same years are selected. Here two years (1983-1984) monsoon months' data was selected for study. Monthly monsoon data (June-July-August-September, JJAS) for target and base stations are calculated and is used as input for various methods. Those neighbouring stations which are within 30 km range were selected and then the stations which do not have 1983-1984 year data were discarded.

Several methods are available for estimating missing precipitation data. Some methods are quite simple but others require some expertise in statistical analysis, time series analysis, neural networks, spatial analysis, etc. Here we are analyzing four different methods which are stated below:

- **Arithmetic mean**

This method may be applied when the normal annual precipitation at the site of interest (site with the missing record) is within 10% of the normal annual precipitation at other sites where concurrent data are available. Arithmetic procedure could be adopted to estimate the missing observation of station X (Chow et al, 1988). This assumes equal weights from all nearby rain gauge stations and uses the arithmetic mean of precipitation records of them as estimate.

- **Inverse distance method (Distance Power Method)**

In this method, weights for each sample are inversely proportionate to its distance from the point being estimated (Lam, 1983).

- **Aerial Precipitation Ratio (APR) method or Thiessen Polygon method**

This method was developed based on spatial distribution of daily rainfall without accounting for the historical recurrence. The method leads the extension of point rainfall records to Thiessen Polygon areas. The APR method assumes the contribution of rainfall from surrounding stations is proportionate to the aerial contribution of each sub catchment (Thiessen polygon area claimed by each station without considering the missing gauge), when the station of missing values is excluded (De Silva, 1997).

- **Normal Ratio method**

This method is used if any surrounding gauges have the normal annual precipitation exceeding 10% of the considered gauge. This weighs the effect of each surrounding station (Singh, 1994).

Although this method was considered for analysis but it was not satisfying the criteria as stated above hence interpolated value from Normal ratio method could not be calculated.

2. Sample Calculations

Stations used in the study are shown in the Table 1 below.

Table 1 Target and Base Stations Details Used for the Analysis

Target Station WRIS code	Base Stations WRIS codes	From Year (JJAS)	To Year (JJAS)
21	120	1983	1984
	121	1983	1984
	122	1983	1984

Calculations for arriving at these results are shown below.

- **Arithmetic Mean**

Table 2 Calculation Tables for Arithmetic Mean method

	Month	Observed rain at Station 120,mm	Observed rain at Station 121, mm	Observed rain at Station 122, mm	Arithmetic Mean, mm
	C1	C2	C3	C4	C5 =(C2+C3+C4)/ 3
R1	Jun-83	42.0	82.7	48.0	57.6
R2	Jul-83	481.0	282.5	150.0	304.5
R3	Aug-83	311.0	257.4	164.0	244.1
R4	Sep-83	224.4	287.2	195.0	235.5
R5	Jun-84	36.0	26.6	18.0	26.9
R6	Jul-84	79.0	139.4	25.0	81.1
R7	Aug-84	172.0	266.4	215.0	217.8
R8	Sep-84	98.0	56.2	34.0	62.7

Month	Calculation	Value, mm
Mean of June	(57.56 + 26.86) /2	42.21
Mean of July	(304.5 + 81.13) /2	192.81
Mean of August	(244.13 + 217.8) /2	230.96
Mean of September	(235.53 + 62.73) /2	149.13

- **Thiessen Polygon Method**

Thiessen Weights of various raingauge stations are presented in Table 3:

Table 3: Stations showing respective Thiessen weights

Station	Thiessen weights
120	0.15
121	0.43
122	0.43

Observed rainfall in month of June is presented in Table 4

Table 4 Observed rainfall in Month of June

Month	Observed rain at Station 120,mm	Observed rain at Station 121, mm	Observed rain at Station 122, mm
June 83	42	82.7	48
June 84	36	26.6	18

Sample calculation of rainfall using Thiessen Polygons method for the month of June is presented in Table 5

Table 5 Sample calculation for Month of June for Thiessen method

Month	Calculation ∑ (Monthly value * Thiessen weight)	Value, mm
Jun-83	(42 * 0.15)+ (82.7 * 0.43) + (48 * 0.43)	62.0
Jun-84	(36*0.15)+(26.6*0.43)+(18*0.43)	24.3
Mean of June	(62.0+ 24.3)/2	**43.1**

- **IDW Method**

Target station: Base stations distances are presented in Table 6:

Table 6: Target to Base Station Distance, km

Target station	Base station	Distance, km
21	121	13
	122	13
	120	12

Rainfall observed in 3 stations in June 1983 and 1984 is presented in Table 7

Table 7: Observed Rainfall in Month of June

Month	Observed rain at Station 120, mm	Observed rain at Station 121, mm	Observed rain at Station 122, mm
June 1983	42	82.7	48
June 1984	36	26.6	18

A sample calculation of rainfall using IDW method for the month of June 1983 and 1984 is presented in Table 8.

Table 8: Sample calculation for month of June for IDW

Month	Rainfall/(Dist)^2	Rainfall/(Dist)^2	Rainfall/(Dist)^2	Sum
June 83	$42/(12)^2 = 0.27$	$82.7/(13)^2 = 0.46$	$48/(13)^2 = 0.27$	(0.27+0.46+ 0.27) = 1.00
June 84	$36/(12)^2 = 0.23$	$26.6/13)^2 = 0.15$	$18/(13)^2 = 0.10$	(0.23+0.15+0.10) = 0.48

$\sum P_{\text{June 83}}/(\text{dist})^2 = 1.00$

$\sum P_{\text{June 84}}/(\text{dist})^2 = 0.48$

$\sum 1\backslash(\text{dist})^2 = 0.01$

Mean of June = (1.00/0.01) + (0.48/0.01) = 42.04 mm

3. Summary and Conclusions

After analyzing the four methods it was found that IDW (Inverse Distance Weighted method) is giving the nearest results to the observed value. A comparison of all the methods is shown in Table 9.

Table 9: Estimated Missing Rainfall by Various Methods, mm

Month	Long term Annual Mean. JJAS , mm (WRIS :21)	Arithmetic Mean., mm	IDW, mm	APR\ Thiessen, mm	Normal Ratio, mm
June	74.56	42.21	42.04	43.12	NA
July	262.27	192.81	197.59	168.19	NA
August	258.40	230.96	231.54	227.99	NA
September	73.37	149.13	149.80	145.72	NA
Annual Mean in JJAS	167.15	153.78	158.91	146.25	NA
Difference (Obs. value - Respective methods' value)		-13.37	-11.91	-20.89	NA

Inference can be drawn from above Table that the interpolated rainfall value from IDW method is only 11.91 mm less than the observed value, whereas Arithmetic Mean and APR\Thiessen methods are 13.37 mm and 20.89 mm less than the observed value. Normal Ratio could not be used because neighbouring stations were not satisfying the required criteria. Hence it is concluded that IDW method is better than rest of the methods for this region.

Appendix 5

Trend Analysis Using Mann Kendall Test Statistics

1. Introduction

A climate time series is generally not statistically independent but is comprised of patterns of persistence, cycles, trends or other non-random components. This Appendix describes the statistical approach used to investigate the presence of trend and periodicity in climatic time series. There are several approaches to detect trend in the time series. These can be either parametric or non-parametric. The most popularly used non parametric tests for detecting trend in time series is the Mann-Kendall (MK). The Mann-Kendal approach is used to detect significant trends in the selected years. The slope of the data set is computed using the Thiel-Sen Approach (TSA). For the present study a 5-percent level of significance was selected to indicate the presence of statistically significant trends over the period of 30 years (1961 – 1990).

2. Non Parametric Versus Parametric Methods

The assumption of the parametric approach (i.e. normality, linearity and independence) is mostly not satisfied by climatologic data (Huth and Pokorna, 2004; Van Belle and Hughes, 1984; Helsel and Hirsch, 1988). A statistical trend analysis was performed to determine the existence of significant time trends in annual stream flows and precipitation at each of the representative locations. For the detection of the statistical significance of a trend, non-parametric methods have been used in several studies (Zhang et al, 2001; Huth and Pokorna, 2004; Harry et al, 1999; Kahya, and Kalayci, 2004; Xu et al, 2003; Partal and Kalya, 2006 and Yue and Hashimoto, 2003).

Non-parametric methods were found to be suitable for data commonly skewed, and the sample size is large (Hirsch et al, 1982). Non-parametric methods not only tend to be more resistant to misbehaviour of the data (e.g. outliers) but also give results close to their parametric counterparts and lie well within the confidence limits even though the distributions are normal (Huth and Pokorna, 2004). It makes no assumptions on the distribution of the data. Considering the point discussed above, it is suitable to use non parametric methods for trend analysis. Some researchers have used the non-parametric method and the results were satisfactory (Zhang etal, 2001; Huth and Pokorna, 2004; Harry et al, 1999; Kahya and Kalayci, 2004; Xu, 2003; Partal and Kalya, 2006 and Yue and Hashimoto, 2003).

Non-parametric tests are more robust than their parametric counterparts. Speaking on the power of the test, i.e. ability to distinguish between the null hypothesis and alternative hypothesis, the Mann-Kendall tests (Mann, 1945 and Kendall, 1975) for monotonic trends perform well in comparison to the parametric test (Van Belle and Hughes, 1984). Mann-Kendall test is used to test for trends over time. This test is non-parametric, has been widely used to test for randomness against trend in hydrology and climatology (e.g. Burn and Elnur, 2002; Zhang et al 2000; and Pokorna, 2004; Harry et al, 1999; Kahya and Kalayci, 2004; Xu, 2003; Partal and Kalya, 2006 and Yue and Hashimoto 2003).

3. Methodology

This study uses the Zhang method (described in Wang and Swail, 2001) to analyze trends in climate parameters using R software. The pre-whitened trend computation methods are used. The magnitude of the trend is computed using the Theil-Sen approach (TSA). In the Zhang method, the trend is removed from the series if it is significant and the autocorrelation is computed. This process is continued until the differences in the estimates of the slope and the AR (1) in two consecutive iterations are smaller than 1 percent. The Mann-Kendall test for trend is then run on the resulting time series and TSA is used to compute the slope of the trend. Mann Kendall test computes Kendall’s Tau non parametric correlation coefficient and its test of significance (Helsel and Hirsch, 2002) for any pair of X, Y data. If X is time, the test is the test for trend in the Y variable (Mann, 1945).

The Mann-Kendall tests are based on the calculation of Kendall's Tau measure of association between two samples, which is itself based on the ranks in the samples. The Mann Kendall test has two parameters of importance for trend detection. These are the significance level, which indicates the test strength, and the slope magnitude estimate, which indicates the direction as well as magnitude of the trend. Kendall’s Tau is a measure of correlation. It measures the strength of association between the two variables. Kendall’s Tau is carried out on the ranks of the data. That is, for each variable separately the values are placed in an order and numbered 1 for the lowest value, 2 for the next lowest and so on. In common with other measures of correlation, Kendall’s Tau will take values between +1 and -1, with a positive correlation indicating that ranks of both the variables increase together whilst a negative correlation indicates that as the rank of one variable increases the other one decreases.

If we allow for 10% error, then with 90% confidence we can say that there is a statistically significant trend in the data.

The higher the confidence level (100 significance), the higher will be Tau value, so the trend is strong.

Appendix 6

Target to Base Station Index, Along with Respective Distances for Double Mass Curve and Rainfall Gap Filling Analysis

For each of the raingauge stations used in the analysis, their respective base stations list is presented in Table 1 below, along with the respective distances from target stations. This target-to-base-stations list is used in rainfall gap filling and double mass curve analysis. These base stations were selected within a 30 km range of the target station.

Table 1 Target Raingauge Stations and their Respective Base Stations

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
1	12	16
	15	16
	17	17
	52	24
	636	26
3	275	20
	283	21
4	19	25
	53	29
	565	8
	695	16
5	68	25
	697	30
6	280	28
	283	11
	692	21
8	9	10
	200	30
	202	28
	204	23
	673	0
	850	30
	852	28
9	8	10
	200	23
	202	27
	204	15
	673	10
	850	23
	852	27
12	1	16
	15	24
	17	25
	43	23
15	1	16
	12	24
	17	2
	19	16
	22	20
	52	21
	636	17
	659	25
	695	24
17	1	17
	12	25
	15	2
	19	15
	22	21
	52	20
	636	15
	659	23
	695	23
19	4	25
	15	16
	17	15
	22	23
	52	22
	565	27
	636	12
	659	16
	695	11
21	120	12
	121	15
	122	15
	788	27
22	15	20
	17	21
	19	23
	663	26
	695	22

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	699	23
	707	29
	825	30
25	34	24
26	31	23
	33	21
	641	23
	661	13
30	264	20
	269	30
	308	29
	310	16
	313	17
	314	0
	525	0
	545	24
	820	15
31	26	23
	32	23
	33	23
	36	19
	37	22
	38	28
	42	23
	641	0
	661	20
32	31	23
	36	27
	37	29
	39	26
	641	23
	661	25
	838	29
33	26	21
	31	23
	38	21
	62	25
	641	23
	661	29
34	25	24
36	31	19
	32	27
	37	3
	42	7
	45	26
	641	19

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	838	28
37	31	22
	32	29
	36	3
	42	6
	45	24
	641	22
	825	30
	838	28
38	31	28
	33	21
	42	26
	46	24
	641	28
	707	30
	825	30
39	32	26
	838	24
40	45	28
	653	2
	838	13
42	31	23
	36	7
	37	6
	38	26
	45	24
	641	23
	707	30
	825	25
43	12	23
	46	24
	49	20
	60	20
	64	30
	647	20
45	36	26
	37	24
	40	28
	42	24
	653	26
	663	15
	699	24
	825	27
	838	29
46	38	24
	43	24

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	49	28
	60	28
	647	28
	699	30
	707	17
	825	23
48	50	20
	52	15
	629	25
	636	24
	659	22
	683	17
	860	0
49	43	20
	46	28
	60	0
	63	16
	64	26
	647	0
	681	25
50	48	20
	117	22
	125	20
	130	18
	658	23
	683	11
	829	26
	860	20
51	127	24
	671	15
	843	26
	861	21
52	1	24
	15	21
	17	20
	19	22
	48	15
	629	27
	636	10
	659	13
	860	15
53	4	29
	68	28
	162	19
	629	16
	659	26
	697	18
57	58	17
	65	30
	577	17
	671	21
	788	17
	843	14
	861	28
58	57	17
	121	24
	122	24
	577	0
	668	20
	671	25
	788	8
	843	8
	861	16
59	61	29
	62	30
	63	26
	853	27
60	43	20
	46	28
	49	0
	63	16
	64	26
	647	0
	681	25
61	59	29
	62	9
	649	14
62	33	25
	59	30
	61	9
	649	19
63	49	16
	59	26
	60	16
	64	29
	66	19
	647	16
	681	11
	853	16
64	43	30
	49	26
	60	26

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	63	29
	65	27
	66	30
	647	26
	681	29
65	57	30
	64	27
66	63	19
	64	30
	681	8
	853	16
68	5	25
	53	28
	162	29
	697	13
	701	21
	733	15
69	143	24
	150	22
	151	15
	555	22
	701	25
	733	17
70	71	18
	72	20
	80	19
	115	25
	643	25
	651	28
	660	17
	676	5
	712	20
	750	20
71	70	18
	72	5
	80	19
	87	23
	94	17
	651	26
	656	23
	676	21
	708	17
	712	24
72	70	20
	71	5
	80	24

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	87	27
	92	24
	94	19
	656	27
	676	22
	708	19
	712	20
73	81	28
	115	26
	153	24
	660	22
	750	17
76	99	28
	105	21
	581	25
	672	27
	680	0
	778	23
	779	29
	790	21
	840	22
77	292	12
	294	19
	298	19
	304	19
	307	6
	323	19
	582	14
	718	0
	828	27
	834	17
78	81	17
	99	13
	102	19
	108	29
	109	29
	651	25
	665	16
	779	5
80	70	19
	71	19
	72	24
	81	24
	87	21
	651	9
	656	21

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	660	16
	676	24
81	73	28
	78	17
	80	24
	99	29
	102	28
	651	19
	660	21
	665	17
	779	19
84	87	20
	94	30
	98	25
	99	28
	102	16
	104	25
	108	9
	109	9
	656	20
	708	30
85	86	28
	89	26
	90	26
	93	24
	94	26
	95	24
	98	16
	632	28
	708	26
86	85	28
	90	17
	95	29
	98	28
	280	23
	632	3
87	71	23
	80	21
	84	20
	94	12
	98	24
	102	23
	108	27
	651	20
	656	0
	708	12
89	85	26
	92	17
	93	24
	96	26
	97	24
	146	26
90	85	26
	86	17
	98	18
	632	14
	735	29
92	71	29
	72	24
	89	17
	96	24
	97	22
	146	24
	686	16
	712	27
93	85	24
	89	24
	95	9
94	71	17
	72	19
	80	25
	84	30
	85	26
	87	12
	98	24
	651	28
	656	12
	708	0
95	85	24
	86	29
	93	9
	280	24
96	89	26
	92	24
	97	2
	146	0
	686	26
97	89	24
	92	22
	96	2
	146	2
	686	25

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
98	84	25
	85	16
	86	28
	87	24
	90	18
	94	24
	632	27
	656	24
	708	24
99	76	28
	78	13
	102	15
	104	20
	105	27
	108	20
	109	20
	665	27
	779	15
	846	24
102	78	19
	84	16
	87	23
	99	15
	104	25
	108	13
	109	13
	651	20
	656	23
	779	24
104	84	25
	99	20
	102	25
	105	18
	108	16
	109	16
	581	15
	778	24
	840	18
	846	6
105	76	21
	99	27
	104	18
	581	4
	672	21
	680	21
	778	7

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	790	30
	840	1
	846	13
108	78	29
	84	9
	87	27
	99	20
	102	13
	104	16
	109	0
	656	27
	846	23
109	78	29
	84	9
	87	27
	99	20
	102	13
	104	16
	108	0
	656	27
	846	23
111	113	12
	114	9
	143	22
	568	13
	643	21
	686	16
	712	20
113	111	12
	114	5
	143	15
	149	29
	568	2
	643	19
	686	28
	712	26
114	111	9
	113	5
	143	19
	568	6
	643	16
	686	25
	712	22
115	70	25
	73	26
	134	25

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	153	28
	643	24
	660	27
	676	23
	677	28
	710	15
	750	13
116	134	15
	137	26
	141	10
	142	12
	148	23
	152	14
	677	12
	700	28
	710	26
117	50	22
	125	21
	130	27
	162	28
	658	21
	683	22
	701	27
	829	16
120	21	12
	121	26
	122	26
	197	30
121	21	15
	58	24
	120	26
	122	0
	577	24
	650	25
	668	20
	788	20
122	21	15
	58	24
	120	26
	121	0
	577	24
	650	25
	668	20
	788	20
125	50	20
	117	21

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	128	22
	130	8
	658	3
	683	29
127	51	24
	128	30
	130	25
	131	22
128	125	22
	127	30
	130	25
	131	15
	135	22
	164	30
	658	20
130	50	18
	117	27
	125	8
	127	25
	128	25
	658	11
	683	29
131	127	22
	128	15
	164	20
132	133	0
	176	24
	177	17
	179	25
	797	17
133	132	0
	176	24
	177	17
	179	25
	797	17
134	115	25
	116	15
	137	26
	141	16
	142	25
	152	19
	677	7
	710	11
135	128	22
	157	27
	160	17

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	795	25
136	138	26
	145	27
	148	28
	155	25
	159	28
	343	22
	344	19
	685	27
	780	21
137	116	26
	134	26
	152	12
	153	19
	557	16
	560	17
	677	19
	700	21
	706	18
138	136	26
	139	10
	140	19
	145	2
	149	26
	155	18
	685	1
	780	11
	815	14
139	138	10
	140	12
	145	9
	149	19
	155	25
	685	9
	780	18
	795	27
	815	8
140	138	19
	139	12
	145	18
	147	17
	149	26
	150	23
	555	23
	685	19
	795	15

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	815	17
141	116	10
	134	16
	142	12
	148	20
	149	27
	152	24
	677	19
	710	26
142	116	12
	134	25
	141	12
	148	12
	152	23
	343	29
	677	24
	780	29
143	69	24
	111	22
	113	15
	114	19
	149	22
	150	29
	151	25
	555	29
	568	13
	815	30
145	136	27
	138	2
	139	9
	140	18
	149	26
	155	17
	685	3
	780	13
	815	15
146	89	26
	92	24
	96	0
	97	2
	686	26
147	139	28
	140	17
	150	11
	151	17
	555	11

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	795	11
148	116	23
	136	28
	138	30
	141	20
	142	12
	343	22
	685	29
	780	19
149	138	26
	139	19
	140	26
	141	27
	143	22
	145	26
	685	24
	780	26
	815	12
150	69	22
	140	23
	143	29
	147	11
	151	6
	555	0
	795	22
151	69	15
	140	28
	143	25
	147	17
	150	6
	555	6
	701	29
	733	29
	795	28
152	116	14
	134	19
	137	12
	141	24
	142	23
	557	28
	677	12
	700	19
	706	25
	710	29
153	73	24
	115	28

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	137	19
	152	29
	557	19
	560	14
	677	28
	706	30
	750	30
154	161	27
	163	20
	165	29
	630	17
	776	16
155	136	25
	138	18
	139	25
	145	17
	157	19
	159	27
	160	25
	685	20
	780	26
156	159	26
	161	11
	345	29
	346	21
	423	12
	424	12
	630	30
157	135	27
	155	19
	159	29
	160	10
	163	29
158	243	30
	248	28
	254	0
	255	24
	256	17
	260	20
	514	28
	644	16
	863	30
159	136	28
	155	27
	156	26
	157	29

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	161	16
	344	24
	345	26
	346	28
	423	21
	424	21
160	135	17
	155	25
	157	10
	163	30
	795	28
161	154	27
	156	11
	159	16
	345	28
	346	23
	423	13
	424	13
162	53	19
	68	29
	117	28
	629	13
	659	30
	683	21
	697	17
	701	21
	829	13
163	154	20
	157	29
	160	30
	164	28
	175	21
	776	18
164	128	30
	131	20
	163	28
	175	10
165	154	29
	171	19
	173	30
	427	29
	630	23
	776	19
171	165	19
	427	11
	428	14

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	630	27
173	165	30
	176	30
175	163	21
	164	10
	776	25
176	132	24
	133	24
	173	30
	177	11
	179	16
	182	30
	797	11
177	132	17
	133	17
	176	11
	179	22
	797	0
178	179	25
	193	16
	650	26
	668	20
179	132	25
	133	25
	176	16
	177	22
	178	25
	182	27
	193	30
	797	22
180	181	25
	183	11
	184	11
	185	20
	186	14
	190	20
	222	20
	225	20
	426	28
181	180	25
	182	27
	183	28
	184	28
	185	27
	186	12
	190	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	221	29
	222	23
	225	23
182	176	30
	179	27
	181	27
	185	28
	186	30
	190	28
183	180	11
	181	28
	184	0
	185	11
	186	16
	190	11
	426	30
184	180	11
	181	28
	183	0
	185	11
	186	16
	190	11
	426	30
185	180	20
	181	27
	182	28
	183	11
	184	11
	186	17
	190	0
186	180	14
	181	12
	182	30
	183	16
	184	16
	185	17
	190	17
	222	22
	225	22
187	188	15
	192	23
	193	27
	196	24
	406	13
188	187	15
	192	27
	196	21
	221	22
	406	28
190	180	20
	181	27
	182	28
	183	11
	184	11
	185	0
	186	17
192	187	23
	188	27
	194	19
	196	12
	241	25
	406	26
193	178	16
	179	30
	187	27
	406	17
	650	17
	743	25
194	192	19
	196	28
	197	24
	198	21
	238	29
	241	26
	787	28
196	187	24
	188	21
	192	12
	194	28
	241	20
197	120	30
	194	24
	198	3
	743	27
198	194	21
	197	3
	743	28
199	200	16
	203	12
	204	24
	233	19
	850	16

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	851	19
200	8	30
	9	23
	199	16
	202	19
	203	28
	204	9
	233	13
	850	0
	851	13
	852	19
202	9	27
	200	19
	204	21
	233	14
	234	20
	673	28
	814	20
	850	19
	851	14
	852	0
203	199	12
	200	28
	233	30
	746	28
	850	28
	851	30
204	8	23
	9	15
	199	24
	200	9
	202	21
	233	20
	673	23
	850	9
	851	20
	852	21
206	208	8
	213	20
	217	17
	218	17
	219	29
	232	20
	234	22
	652	8
	814	22

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
208	206	8
	209	28
	213	13
	217	13
	218	21
	232	27
	652	0
209	212	23
	213	16
	215	22
	217	22
	652	28
	831	28
210	211	8
	214	13
	218	20
	219	10
	228	21
	245	25
	657	11
211	210	8
	214	20
	218	28
	219	18
	228	13
	245	27
	657	7
212	209	23
	541	19
	831	21
213	206	20
	208	13
	209	16
	214	21
	217	8
	219	23
	652	13
214	210	13
	211	20
	213	21
	217	15
	218	18
	219	4
	245	17
215	209	22
	214	24

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	219	27
	244	14
	245	10
	246	24
	831	18
217	206	17
	208	13
	213	8
	214	15
	218	17
	219	17
	652	13
218	206	17
	208	21
	210	20
	214	18
	217	17
	219	16
	232	12
	652	21
219	210	10
	211	18
	213	23
	214	4
	217	17
	218	16
	245	20
	657	21
220	226	28
	247	27
	249	8
	453	8
	574	21
	645	17
	800	17
221	181	29
	188	22
	553	16
	645	26
	800	25
222	180	20
	181	23
	186	22
	225	0
	553	20
225	180	20

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	181	23
	186	22
	222	0
	553	20
226	220	28
	228	26
	229	12
	241	22
	645	16
228	210	21
	211	13
	219	30
	226	26
	229	18
	657	13
229	211	29
	226	12
	228	18
	235	30
	240	26
	241	24
	645	26
	657	26
230	202	30
	218	23
	231	8
	232	12
	233	23
	234	22
	814	22
	851	23
231	210	29
	218	22
	230	8
	232	15
	234	30
	236	27
	657	27
	814	30
232	206	20
	208	27
	218	12
	230	12
	231	15
	234	19
	652	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	814	19
233	199	19
	200	13
	202	14
	204	20
	230	23
	234	26
	814	26
	850	13
	851	0
	852	14
234	202	20
	206	22
	218	28
	230	22
	232	19
	233	26
	814	0
	851	26
	852	20
235	229	30
	236	8
	238	24
	240	10
	241	28
	787	18
236	231	27
	235	8
	238	25
	240	19
	787	20
238	194	29
	235	24
	236	25
	240	24
	787	7
240	229	26
	235	10
	236	19
	238	24
	241	18
	787	18
241	192	25
	194	26
	196	20
	226	22
	229	24
	235	28
	240	18
243	158	30
	247	20
	248	21
	250	9
	252	28
	254	30
	514	21
	575	9
	644	17
	863	0
244	215	14
	245	20
	246	20
	248	20
	514	20
	541	25
	831	11
245	210	25
	211	27
	214	17
	215	10
	219	20
	244	20
	246	20
	831	27
246	215	24
	244	20
	245	20
	247	24
	248	25
	249	30
	453	30
	514	25
247	220	27
	243	20
	246	24
	249	19
	250	17
	453	19
	574	27
	575	12
	863	20
248	158	28

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	243	21
	244	20
	246	25
	254	28
	514	0
	575	25
	644	12
	831	25
	863	21
249	220	8
	246	30
	247	19
	453	0
	574	21
	575	30
	645	25
	800	23
250	243	9
	247	17
	248	29
	251	26
	252	26
	514	29
	575	6
	644	26
	863	9
251	250	26
	252	30
	263	28
	574	21
	575	29
	633	13
252	243	28
	250	26
	251	30
	253	23
	256	28
	258	20
	262	14
	263	29
	863	28
253	252	23
	256	26
	257	16
	258	12
	262	20

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
254	158	0
	243	30
	248	28
	255	24
	256	17
	260	20
	514	28
	644	16
	863	30
255	158	24
	254	24
	256	25
	259	13
	260	16
256	158	17
	252	28
	253	26
	254	17
	255	25
	257	22
	258	14
	644	28
257	253	16
	256	22
	258	16
258	252	20
	253	12
	256	14
	257	16
	262	25
259	255	13
	260	19
260	158	20
	254	20
	255	16
	259	19
262	252	14
	253	20
	258	25
	263	20
	803	25
	841	23
263	251	28
	252	29
	262	20
	633	19

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	803	23
	841	6
264	30	20
	269	12
	308	10
	309	21
	310	24
	314	20
	525	20
	545	15
265	266	0
	267	16
	268	30
	270	23
	274	14
	275	29
	310	22
	715	10
266	265	0
	267	16
	268	30
	270	23
	274	14
	275	29
	310	22
	715	10
267	265	16
	266	16
	268	29
	270	14
	271	26
	273	30
	274	7
	275	13
	715	21
268	265	30
	266	30
	267	29
	274	23
	715	23
269	30	30
	264	12
	273	21
	297	29
	308	15
	309	14

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	310	26
	314	30
	525	30
	545	26
270	265	23
	266	23
	267	14
	271	13
	273	19
	274	20
	275	17
	296	20
	297	24
271	267	26
	270	13
	273	16
	275	25
	287	28
	288	28
	296	8
	297	15
	305	24
	848	24
273	267	30
	269	21
	270	19
	271	16
	290	25
	296	18
	297	10
	305	30
	309	22
	848	30
274	265	14
	266	14
	267	7
	268	23
	270	20
	275	17
	715	16
275	3	20
	265	29
	266	29
	267	13
	270	17
	271	25

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	274	17
280	6	28
	86	23
	95	24
	632	26
	692	27
283	3	21
	6	11
	692	22
287	271	28
	288	1
	296	25
	305	26
	692	17
	735	27
	737	27
	848	26
288	271	28
	287	1
	296	25
	305	26
	692	17
	735	27
	737	27
	848	26
290	271	29
	273	25
	295	17
	296	22
	297	16
	305	15
	737	18
	828	26
	833	6
	848	15
292	77	12
	294	9
	295	22
	304	20
	307	13
	323	19
	582	16
	718	12
	828	21
	834	6
294	77	19
	292	9
	295	22
	307	22
	323	16
	324	16
	582	25
	718	19
	828	27
	834	11
295	290	17
	292	22
	294	22
	306	30
	309	28
	582	29
	713	30
	828	17
	833	13
	834	16
296	270	20
	271	8
	273	18
	287	25
	288	25
	290	22
	297	13
	305	16
	737	22
	848	16
297	270	24
	271	15
	273	10
	290	16
	296	13
	305	20
	309	25
	737	26
	833	22
	848	20
298	77	19
	292	30
	304	26
	307	19
	582	24
	718	19
299	304	28

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	306	8
	670	15
	713	14
	735	29
	737	29
	828	23
304	77	19
	292	20
	306	22
	307	13
	582	5
	670	14
	713	15
	718	19
	828	16
	834	20
305	271	24
	287	26
	288	26
	290	15
	296	16
	297	20
	735	26
	737	6
	833	19
	848	0
306	295	30
	299	8
	304	22
	582	26
	670	10
	713	7
	737	29
	828	15
	833	26
307	77	6
	292	13
	294	22
	298	19
	304	13
	323	25
	582	8
	718	6
	828	23
	834	16
308	30	29

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	264	10
	269	15
	309	15
	314	29
	322	24
	525	29
	545	14
309	264	21
	269	14
	273	22
	290	30
	295	28
	297	25
	308	15
	322	29
	545	29
310	30	16
	264	24
	265	22
	266	22
	269	26
	312	27
	314	16
	525	16
	715	23
	820	17
312	310	27
	313	28
	820	16
313	30	17
	310	30
	312	28
	314	17
	525	17
	820	16
314	30	0
	264	20
	269	30
	308	29
	310	16
	313	17
	525	0
	545	24
	820	15
315	320	30
	321	30

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	390	29
	785	24
	862	0
320	105	30
	315	30
	321	0
	672	13
	778	23
	785	18
	790	27
	840	29
	862	30
321	105	30
	315	30
	320	0
	672	13
	778	23
	785	18
	790	27
	840	29
	862	30
322	294	28
	308	24
	309	29
	324	13
	545	27
323	77	19
	292	19
	294	16
	307	25
	324	19
	718	19
	834	24
324	292	26
	294	16
	322	13
	323	19
	834	27
325	331	15
	332	15
	336	28
	390	22
328	333	3
	334	10
	336	17
	390	25

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	409	24
	411	25
	550	27
	847	14
331	325	15
	332	0
	336	25
	390	27
	409	26
	548	19
	550	24
332	325	15
	331	0
	336	25
	390	27
	409	26
	548	19
	550	24
333	328	3
	334	8
	336	17
	390	26
	409	22
	411	22
	550	25
	847	16
334	328	10
	333	8
	336	21
	409	22
	410	30
	411	19
	547	30
	550	25
	696	28
	847	22
336	328	17
	331	25
	332	25
	333	17
	334	21
	390	15
	409	13
	411	21
	550	16
	847	26

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
339	689	24
341	343	16
	348	23
	359	21
	360	21
	802	21
343	136	22
	142	29
	148	22
	341	16
	344	27
	359	29
	360	29
	780	30
	802	29
344	136	19
	159	24
	343	27
	345	13
	346	23
	423	26
	424	26
	682	22
345	156	29
	159	26
	161	28
	344	13
	346	10
	423	17
	424	17
	682	13
346	156	21
	159	28
	161	23
	344	23
	345	10
	423	10
	424	10
	682	17
	689	29
348	341	23
	353	26
	355	25
	359	19
	360	19
	802	19

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
349	350	29
	351	12
	354	24
350	349	29
	354	11
351	349	12
	354	26
	543	26
353	348	26
	355	5
	698	23
354	349	24
	350	11
	351	26
355	348	25
	353	5
	362	28
	698	27
359	341	21
	343	29
	348	19
	360	0
	700	19
	802	0
360	341	21
	343	29
	348	19
	359	0
	700	19
	802	0
361	362	28
	363	27
	365	30
	371	27
	372	24
	375	17
	805	8
	813	25
362	355	28
	361	28
	363	23
	365	20
	562	23
	706	24
	805	27
363	361	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	362	23
	365	5
	371	14
	372	19
	562	10
365	361	30
	362	20
	363	5
	371	19
	372	24
	557	27
	560	30
	562	6
	706	26
371	361	27
	363	14
	365	19
	372	7
	375	25
	562	23
372	361	24
	363	19
	365	24
	371	7
	375	19
	562	29
	563	28
	813	28
374	379	8
	380	13
	382	21
	384	12
	665	30
	721	27
375	361	17
	371	25
	372	19
	563	25
	736	24
	805	24
	813	10
376	563	18
379	374	8
	380	6
	382	17
	384	12

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	561	25
	721	20
380	374	13
	379	6
	382	13
	384	12
	561	19
	721	14
382	374	21
	379	17
	380	13
	384	12
	561	20
	665	28
	721	16
384	374	12
	379	12
	380	12
	382	12
	561	29
	665	22
	721	24
388	389	17
	547	25
	556	0
	561	20
	696	26
	721	22
	837	23
389	388	17
	391	26
	547	20
	556	17
	696	27
	837	19
390	315	29
	325	22
	328	25
	331	27
	332	27
	333	26
	336	15
	409	28
	847	26
	862	29
391	389	26

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	543	20
406	187	13
	188	28
	192	26
	193	17
	650	23
	743	22
409	328	24
	331	26
	332	26
	333	22
	334	22
	336	13
	390	28
	410	25
	411	9
	550	4
410	334	30
	409	25
	411	16
	547	30
	550	24
411	328	25
	333	22
	334	19
	336	21
	409	9
	410	16
	550	11
413	548	21
	714	16
415	544	29
	714	29
420	421	30
	435	29
	854	25
421	420	30
	803	18
	841	28
422	782	24
423	156	12
	159	21
	161	13
	344	26
	345	17
	346	10
	424	0
	682	27
424	156	12
	159	21
	161	13
	344	26
	345	17
	346	10
	423	0
	682	27
426	180	28
	183	30
	184	30
427	165	29
	171	11
	428	8
	430	26
428	171	14
	427	8
	430	19
430	427	26
	428	19
	431	30
	433	30
	741	28
	816	30
431	430	30
	741	19
	816	12
432	433	2
433	430	30
	432	2
435	420	29
	436	28
	437	14
	854	22
436	435	28
	744	26
437	435	14
	744	30
438	439	0
439	438	0
444	445	2
445	444	2
449	526	18
450	451	0

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
451	450	0
453	220	8
	246	30
	247	19
	249	0
	574	21
	575	30
	645	25
	800	23
456	529	11
458	634	30
	678	22
460	464	17
464	460	17
466	490	26
	495	19
	634	27
467	497	11
	822	10
470	471	0
	496	27
	504	24
471	470	0
	496	27
	504	24
475	484	22
	492	28
	497	28
	508	19
	687	26
481	490	24
484	475	22
	492	12
	504	27
	687	5
487	507	8
490	466	26
	481	24
	495	26
492	475	28
	484	12
	502	22
	687	14
495	466	19
	490	26
496	470	27
	471	27
	504	14
	822	24
497	467	11
	475	28
	508	30
	822	12
502	492	22
504	470	24
	471	24
	484	27
	496	14
	687	25
507	487	8
508	475	19
	497	30
510	511	0
511	510	0
514	158	28
	243	21
	244	20
	246	25
	248	0
	254	28
	575	25
	644	12
	831	25
	863	21
516	711	16
518	519	0
	520	2
	752	30
519	518	0
	520	2
	752	30
520	518	2
	519	2
523	524	0
524	523	0
525	30	0
	264	20
	269	30
	308	29
	310	16
	313	17
	314	0

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	545	24
	820	15
526	449	18
529	456	11
532	533	18
533	532	18
	534	26
	535	26
	782	23
534	533	26
	535	0
	782	29
535	533	26
	534	0
	782	29
536	711	27
538	698	28
541	212	19
	244	25
	248	30
	514	30
	831	15
543	351	26
	391	20
544	415	29
	826	17
545	30	24
	264	15
	269	26
	308	14
	309	29
	314	24
	322	27
	525	24
547	334	30
	388	25
	389	20
	410	30
	556	25
	561	22
	696	9
	721	27
	837	2
548	331	19
	332	19
	413	21

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	714	27
550	328	27
	331	24
	332	24
	333	25
	334	25
	336	16
	390	30
	409	4
	410	24
	411	11
553	181	30
	221	16
	222	20
	225	20
	574	28
	800	18
555	69	22
	140	23
	143	29
	147	11
	150	0
	151	6
	795	22
556	388	0
	389	17
	547	25
	561	20
	696	26
	721	22
	837	23
557	137	16
	152	28
	153	19
	365	27
	560	6
	562	21
	700	28
	706	13
560	137	17
	152	29
	153	14
	365	30
	557	6
	562	24
	706	18

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
561	379	25
	380	19
	382	20
	388	20
	547	22
	556	20
	696	16
	721	5
	837	21
562	362	23
	363	10
	365	6
	371	23
	372	29
	557	21
	560	24
	706	23
563	372	28
	375	25
	376	18
	736	25
	813	23
565	4	8
	19	27
	675	26
	695	16
568	111	13
	113	2
	114	6
	143	13
	149	28
	643	21
	686	29
	712	28
574	220	21
	247	27
	249	21
	251	21
	453	21
	553	28
	800	15
575	243	9
	247	12
	248	25
	249	30
	250	6

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	251	29
	453	30
	514	25
	644	25
	863	9
577	57	17
	58	0
	121	24
	122	24
	668	20
	671	25
	788	8
	843	8
	861	16
581	76	25
	99	28
	104	15
	105	4
	672	23
	680	25
	778	9
	840	4
	846	9
582	77	14
	292	16
	298	24
	304	5
	307	8
	670	19
	713	19
	718	14
	828	17
	834	16
629	48	25
	53	16
	162	13
	636	26
	659	18
	683	21
	697	25
	829	24
	860	25
630	154	17
	156	30
	165	23
	171	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	776	22
	816	28
632	85	28
	86	3
	90	14
	98	27
	280	26
	735	30
633	251	13
	263	19
	841	23
634	458	30
	466	27
636	15	17
	17	15
	19	12
	48	24
	52	10
	629	26
	659	8
	695	23
	860	24
641	26	23
	31	0
	32	23
	33	23
	36	19
	37	22
	38	28
	42	23
	661	20
642	684	30
643	70	25
	111	21
	113	19
	114	16
	115	24
	568	21
	676	20
	710	24
	712	15
644	158	16
	243	17
	248	12
	250	26
	254	16
	256	28
	514	12
	575	25
	863	17
645	220	17
	221	26
	226	16
	229	26
	249	25
	453	25
	800	20
647	43	20
	46	28
	49	0
	60	0
	63	16
	64	26
	681	25
649	61	14
	62	19
650	121	25
	122	25
	178	26
	193	17
	406	23
	743	11
651	71	26
	78	25
	80	9
	81	19
	87	20
	94	28
	102	20
	656	20
	660	20
652	206	8
	208	0
	209	28
	213	13
	217	13
	218	21
	232	27
653	40	2
	45	26
	838	14
656	71	23

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	80	21
	84	20
	87	0
	94	12
	98	24
	102	23
	108	27
	651	20
	708	12
657	210	11
	211	7
	214	24
	219	21
	228	13
	229	26
658	50	23
	117	21
	125	3
	128	20
	130	11
659	15	25
	17	23
	19	16
	48	22
	52	13
	629	18
	636	8
	695	25
	860	22
660	70	17
	71	29
	73	22
	80	16
	81	21
	115	27
	651	20
	676	20
	750	15
661	26	13
	31	20
	32	25
	33	29
	641	20
663	22	26
	45	15
	699	14

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	707	27
	825	22
665	78	16
	81	17
	99	27
	374	30
	382	28
	384	22
	779	13
668	58	20
	121	20
	122	20
	178	20
	577	20
	788	24
	843	26
	861	20
670	299	15
	304	14
	306	10
	307	27
	582	19
	713	4
	828	17
	834	30
671	51	15
	57	21
	58	25
	577	25
	843	17
	861	22
672	76	27
	105	21
	320	13
	321	13
	581	23
	680	27
	778	14
	785	14
	790	17
	840	20
673	8	0
	9	10
	200	30
	202	28
	204	23

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	850	30
	852	28
675	565	26
676	70	5
	71	21
	72	22
	80	24
	115	23
	643	20
	660	20
	712	16
	750	20
677	115	28
	116	12
	134	7
	137	19
	141	19
	142	24
	152	12
	153	28
	710	17
678	458	22
680	76	0
	99	28
	105	21
	581	25
	672	27
	778	23
	779	29
	790	21
	840	22
681	49	25
	60	25
	63	11
	64	29
	66	8
	647	25
	853	12
682	344	22
	345	13
	346	17
	423	27
	424	27
683	48	17
	50	11
	117	22
	125	29
	130	29
	162	21
	629	21
	829	19
	860	17
684	642	30
685	136	27
	138	1
	139	9
	140	19
	145	3
	149	24
	155	20
	780	11
	815	13
686	92	16
	96	26
	97	25
	111	16
	113	28
	114	25
	146	26
	568	29
	712	22
687	475	26
	484	5
	492	14
	504	25
689	339	24
	346	29
692	6	21
	280	27
	283	22
	287	17
	288	17
695	4	16
	15	24
	17	23
	19	11
	22	22
	565	16
	636	23
	659	25
696	334	28
	388	26

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	389	27
	547	9
	556	26
	561	16
	721	21
	837	9
697	5	30
	53	18
	68	13
	162	17
	629	25
	701	18
	733	22
	829	24
698	353	23
	355	27
	538	28
699	22	23
	45	24
	46	30
	663	14
	707	12
	825	9
700	116	28
	137	21
	152	19
	359	19
	360	19
	557	28
	706	18
	802	19
701	68	21
	69	25
	117	27
	151	29
	162	21
	697	18
	733	16
	829	17
706	137	18
	152	25
	153	30
	362	24
	365	26
	557	13
	560	18

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	562	23
	700	18
707	22	29
	38	30
	42	30
	46	17
	663	27
	699	12
	825	6
708	71	17
	72	19
	80	25
	84	30
	85	26
	87	12
	94	0
	98	24
	651	28
	656	12
710	115	15
	116	26
	134	11
	141	26
	152	29
	643	24
	677	17
	750	27
711	516	16
	536	27
712	70	20
	71	24
	72	20
	92	27
	111	20
	113	26
	114	22
	643	15
	676	16
	686	22
713	295	30
	299	14
	304	15
	306	7
	307	27
	582	19
	670	4

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	828	13
	833	29
	834	27
714	413	16
	415	29
	548	27
715	265	10
	266	10
	267	21
	268	23
	274	16
	310	23
716	798	28
718	77	0
	292	12
	294	19
	298	19
	304	19
	307	6
	323	19
	582	14
	828	27
	834	17
721	379	20
	380	14
	382	16
	384	24
	388	22
	556	22
	561	5
	696	21
	837	26
733	68	15
	69	17
	151	29
	697	22
	701	16
735	90	29
	287	27
	288	27
	299	29
	305	26
	632	30
	737	21
	848	26
736	375	24

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	563	25
	813	14
737	287	27
	288	27
	290	18
	296	22
	297	26
	305	6
	306	29
	735	21
	833	20
	848	6
741	430	28
	431	19
	816	30
743	193	25
	197	27
	198	28
	406	22
	650	11
744	436	26
	437	30
746	203	28
750	70	20
	73	17
	80	30
	115	13
	153	30
	660	15
	676	20
	710	27
752	518	30
	519	30
	805	27
776	154	16
	163	18
	165	19
	175	25
	630	22
778	76	23
	104	24
	105	7
	320	23
	321	23
	581	9
	672	14

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	680	23
	840	7
	846	19
779	76	29
	78	5
	81	19
	99	15
	102	24
	651	29
	665	13
	680	29
780	136	21
	138	11
	139	18
	145	13
	148	19
	149	26
	155	26
	685	11
	815	18
782	422	24
	533	23
	534	29
	535	29
785	315	24
	320	18
	321	18
	672	14
	778	28
	790	13
	847	27
	862	24
787	194	28
	235	18
	236	20
	238	7
	240	18
788	21	27
	57	17
	58	8
	121	20
	122	20
	577	8
	668	24
	843	15
	861	25
790	76	21
	105	30
	320	27
	321	27
	672	17
	680	21
	778	26
	785	13
	840	29
	847	22
795	135	25
	139	27
	140	15
	145	30
	147	11
	150	22
	151	28
	160	28
	555	22
797	132	17
	133	17
	176	11
	177	0
	179	22
798	716	28
800	220	17
	221	25
	249	23
	453	23
	553	18
	574	15
	645	20
802	341	21
	343	29
	348	19
	359	0
	360	0
	700	19
803	262	25
	263	23
	421	18
	841	19
805	361	8
	362	27
	375	24
	752	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	813	30
813	361	25
	372	28
	375	10
	563	23
	736	14
	805	30
814	202	20
	206	22
	218	28
	230	22
	232	19
	233	26
	234	0
	851	26
	852	20
815	138	14
	139	8
	140	17
	143	30
	145	15
	149	12
	685	13
	780	18
816	430	30
	431	12
	630	28
	741	30
820	30	15
	310	17
	312	16
	313	16
	314	15
	525	15
822	467	10
	496	24
	497	12
825	22	30
	37	30
	38	30
	42	25
	45	27
	46	23
	663	22
	699	9
	707	6
826	544	17
828	292	21
	295	17
	304	16
	306	15
	307	23
	582	17
	670	17
	713	13
	833	19
	834	16
829	50	26
	117	16
	162	13
	629	24
	683	19
	697	24
	701	17
831	212	21
	215	18
	244	11
	245	27
	248	25
	514	25
	541	15
833	290	6
	295	13
	296	29
	297	22
	305	19
	306	26
	737	20
	828	19
	834	27
	848	19
834	77	17
	292	6
	294	11
	295	16
	304	20
	307	16
	323	24
	582	16
	718	17
	828	16
837	388	23

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	389	19
	547	2
	556	23
	561	21
	696	9
	721	26
838	32	29
	36	28
	37	28
	39	24
	40	13
	45	29
	653	14
840	76	22
	99	28
	104	18
	105	1
	320	29
	581	4
	672	20
	680	22
	778	7
	846	13
841	262	23
	263	6
	421	28
	633	23
	803	19
843	51	26
	57	14
	58	8
	577	8
	668	26
	671	17
	788	15
	861	14
846	99	24
	104	6
	105	13
	108	23
	109	23
	581	9
	778	19
	840	13
847	328	14
	333	16
	334	22
	336	26
	390	26
	785	27
	790	22
848	271	24
	287	26
	288	26
	290	15
	296	16
	297	20
	305	0
	735	26
	737	6
	833	19
850	8	30
	9	23
	199	16
	200	0
	202	19
	203	28
	204	9
	233	13
	851	13
	852	19
851	199	19
	200	13
	202	14
	204	20
	230	23
	233	0
	234	26
	814	26
	850	13
	852	14
852	9	27
	200	19
	202	0
	204	21
	233	14
	234	20
	673	28
	814	20
	850	19
	851	14
853	59	27

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	63	16
	66	16
	681	12
854	420	25
	435	22
860	48	0
	50	20
	52	15
	629	25
	636	24
	659	22
	683	17
861	51	21
	57	28
	58	16
	577	16
	668	20
	671	22
	788	25
	843	14
862	315	0
	320	30
	321	30
	390	29
	785	24
863	17	15
	19	12
	32	7
	36	27
	37	29
	39	20
	48	24
	52	10
	78	17
	80	24
	81	0
	99	29
	102	28
	117	21
	125	0
	128	37
	130	8
	131	0
	133	25
	138	27
	139	28

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	141	14
	142	43
	148	34
	149	21
	155	25
	157	10
	158	30
	160	0
	163	30
	164	20
	171	20
	173	22
	176	46
	177	22
	178	24
	179	0
	182	27
	188	15
	192	23
	193	57
	196	24
	208	13
	209	16
	211	49
	212	23
	213	37
	214	67
	215	22
	217	45
	218	57
	219	102
	226	54
	228	26
	229	30
	230	8
	231	17
	232	35
	234	30
	236	27
	241	22
	243	0
	244	39
	245	27
	246	24
	247	47
	248	51

Target Station (WRIS code)	Base Station (WRIS code)	Distance, km
	249	8
	250	9
	252	28
	254	30
	341	16
	343	0
	344	27
	359	29
	360	29
	382	28
	388	13
	389	22
	406	13
	427	38
	428	14
	453	8
	514	51
	541	19
	547	18
	556	13
	561	9
	574	21
	575	9
	629	26
	630	27
	636	0
	641	29
	644	17
	645	33
	651	19
	652	41
	657	53
	658	3
	659	8
	660	21
	665	17
	683	29
	685	26
	695	23
	696	15
	721	13
	776	28
	779	19
	780	49
	795	28
	797	22
	800	17
	802	29
	814	30
	815	22
	831	82
	837	16
	838	22
	860	24

Appendix 7

Summary of Rain Gauging Stations Data

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
196	Moran Sagar *	WRD Stations	26°39'48"	76°32'20"	Bamanwas	Sawai Madhopur	IIIb	1958	2010	6360	9	588	Yes
192	Bamanwas	Revenue Dpt.	26°33'27"	76°33'40"	Bamanwas	Sawai Madhopur	IIIb	1957	2010	6480	0	8	Yes
252	Bansur	Revenue Dpt.	27°40'60"	76°20'60"	Bansur	Alwar	IIIb	1957	2010	6480	0	7	Yes
204	Talabshahi *	WRD Stations	26°37'60"	77°40'60"	Bari	Dhaulpur	IIIb	1959	2010	6240	4	261	Yes
850	Bari *	WRD Stations	26°38'60"	77°35'60"	Bari	Dhaulpur	IIIb	0	0	0	0	0	No
200	Bari	Revenue Dpt.	26°38'60"	77°35'60"	Bari	Dhaulpur	IIIb	1957	2010	6480	1	30	Yes
851	Baseri *	WRD Stations	26°45'00"	77°31'60"	Baseri	Dhaulpur	IIIb	0	0	0	0	0	No
852	Sepau *	WRD Stations	26°49'00"	77°39'00"	Baseri	Dhaulpur	IIIb	0	0	0	0	0	No
202	Sepau	Revenue Dpt.	26°49'00"	77°39'00"	Baseri	Dhaulpur	IIIb	1957	2010	6480	2	101	Yes
233	Baseri	Revenue Dpt.	26°45'00"	77°31'60"	Baseri	Dhaulpur	IIIb	1957	2010	6480	1	31	Yes
199	Angai *	WRD Stations	26°36'00"	77°27'00"	Baseri	Dhaulpur	IIIb	1958	2010	6360	9	557	Yes
203	Sirmathura	Revenue Dpt.	26°31'31"	77°21'39"	Baseri	Dhaulpur	IIIb	1957	2010	6480	1	46	Yes
230	Baretha *	WRD Stations	26°53'60"	77°22'00"	Bayana	Bharatpur	IIIb	1965	2010	5520	2	120	Yes
0	Bayana *	WRD Stations	26°53'60"	77°16'60"	Bayana	Bharatpur	IIIb	0	0	0	0	0	No
231	Bayana	Revenue Dpt.	26°53'60"	77°16'60"	Bayana	Bharatpur	IIIb	1957	2010	6480	1	56	Yes
232	Sewla Head *	WRD Stations	27°00'13"	77°22'52"	Bayana	Bharatpur	IIIb	0	0	0	0	0	No
258	Sodawas *	WRD Stations	27°51'41"	76°24'17"	Behror	Alwar	IIIb	1966	2010	5400	5	259	Yes
253	Behror	Revenue Dpt.	27°52'60"	76°16'60"	Behror	Alwar	IIIb	1957	2010	6480	0	16	Yes
650	Bhadoti *	WRD Stations	26°14'43"	76°22'22"	Bonli	Sawai Madhopur	IIIb	0	0	0	0	0	No
193	Bonli	Revenue Dpt.	26°19'45"	76°13'37"	Bonli	Sawai Madhopur	IIIb	1959	2010	6240	0	15	Yes
743	Malarna Dungar	Revenue Dpt.	26°17'18"	76°28'14"	Bonli	Sawai Madhopur	IIIb	0	0	0	0	0	No
406	Morel Dam *	WRD Stations	26°26'48"	76°19'55"	Bonli	Sawai Madhopur	IIIb	1962	1999	4560	16	732	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
0	Deeg *	WRD Stations	27°26'60"	77°19'00"	Deeg	Bharatpur	IIIb	0	0	0	0	0	No
209	Deeg	Revenue Dpt.	27°26'60"	77°19'00"	Deeg	Bharatpur	IIIb	1957	2010	6480	0	24	Yes
9	Urmila Sagar *	WRD Stations	26°38'10"	77°49'55"	Dhaulpur	Dhaulpur	IIIb	1959	2010	6240	5	323	Yes
673	Dholpur (A)	IMD Stations	26°41'60"	77°54'00"	Dhaulpur	Dhaulpur	IIIb	1957	1999	5160	5	251	Yes
8	Dholpur	Revenue Dpt.	26°41'60"	77°54'00"	Dhaulpur	Dhaulpur	IIIb	1957	2010	6480	0	23	Yes
194	Gangapur City	Revenue Dpt.	26°28'43"	76°43'43"	Gangapur	Sawai Madhopur	IIIb	1957	2010	6480	0	0	Yes
240	Sri Mahavirji *	WRD Stations	26°42'10"	76°54'48"	Hindaun	Karauli	IIIb	0	0	0	0	0	No
236	Juggar *	WRD Stations	26°43'00"	77°05'60"	Hindaun	Karauli	IIIb	1966	2010	5400	9	474	Yes
235	Hindaun	Revenue Dpt.	26°43'00"	77°00'60"	Hindaun	Karauli	IIIb	1957	2010	6480	1	78	Yes
0	Kaman *	WRD Stations	27°38'60"	77°15'60"	Kaman	Bharatpur	IIIb	0	0	0	0	0	No
212	Kaman	Revenue Dpt.	27°38'60"	77°15'60"	Kaman	Bharatpur	IIIb	1957	2010	6480	0	9	Yes
238	Karauli	Revenue Dpt.	26°30'00"	77°00'60"	Karauli	Karauli	IIIb	1957	2010	6480	1	70	Yes
787	Panchna Dam *	WRD Stations	26°33'30"	77°00'00"	Karauli	Karauli	IIIb	0	0	0	0	0	No
245	Kathumbar	Revenue Dpt.	27°19'60"	77°04'00"	Kathumar	Alwar	IIIb	1957	2010	6480	0	16	Yes
158	Kishangarh	Revenue Dpt.	27°49'00"	76°43'00"	Kishangarh Bas	Alwar	IIIb	1958	2010	6360	0	0	Yes
254	Kishangarh Bas	Revenue Dpt.	27°49'00"	76°43'00"	Kishangarh Bas	Alwar	IIIb	1957	2010	6480	0	1	Yes
644	Bahadurpur	Revenue Dpt.	27°40'07"	76°44'20"	Kishangarh Bas	Alwar	IIIb	0	0	0	0	0	No
255	Kotkasim	Revenue Dpt.	28°01'60"	76°43'00"	Kotkasim	Alwar	IIIb	1957	2010	6480	0	1	Yes
217	Sewar *	WRD Stations	27°15'00"	77°20'00"	Kumher	Bharatpur	IIIb	1959	2010	6240	3	160	Yes
0	Kumher *	WRD Stations	27°19'00"	77°22'00"	Kumher	Bharatpur	IIIb	0	0	0	0	0	No
213	Kumher	Revenue Dpt.	27°19'00"	77°22'00"	Kumher	Bharatpur	IIIb	1957	2010	6480	0	24	Yes
244	Govindgarh	Revenue Dpt.	27°30'00"	77°00'00"	Lachhmangarh	Alwar	IIIb	1957	2010	6480	1	31	Yes
246	Laxmangarh	Revenue Dpt.	27°22'00"	76°52'00"	Lachhmangarh	Alwar	IIIb	0	0	0	0	0	No
0	Mahuwa *	WRD Stations	27°03'00"	76°54'60"	Mahwa	Dausa	IIIb	0	0	0	0	0	No
228	Mahuwa	Revenue Dpt.	27°03'00"	76°54'60"	Mahwa	Dausa	IIIb	1957	2010	6480	4	236	Yes
256	Mandawar	Revenue Dpt.	27°52'00"	76°32'60"	Mandawar	Alwar	IIIb	1957	2010	6480	0	9	Yes
218	Uchain *	WRD Stations	27°06'00"	77°19'00"	Nadbai	Bharatpur	IIIb	0	0	0	0	0	No
0	Nadbai *	WRD Stations	27°13'00"	77°10'60"	Nadbai	Bharatpur	IIIb	0	0	0	0	0	No
214	Nadbai	Revenue Dpt.	27°13'00"	77°10'60"	Nadbai	Bharatpur	IIIb	1957	2010	6480	0	8	Yes
219	Weir	Revenue Dpt.	27°10'60"	77°10'60"	Nadbai	Bharatpur	IIIb	1957	2010	6480	1	69	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
241	Nadoti	Revenue Dpt.	26°43'00"	76°43'60"	Nadoti	Karauli	IIIb	1957	2010	6480	1	63	Yes
257	Neemrana	Revenue Dpt.	28°00'00"	76°22'60"	Nimrana	Alwar	IIIb	1957	2010	6480	0	17	Yes
0	Nagar *	WRD Stations	27°25'00"	77°05'60"	Pahari	Bharatpur	IIIb	0	0	0	0	0	No
831	Sikari *	WRD Stations	27°34'33"	77°04'28"	Pahari	Bharatpur	IIIb	0	0	0	0	0	No
0	Pahari *	WRD Stations	27°42'38"	77°05'05"	Pahari	Bharatpur	IIIb	0	0	0	0	0	No
215	Nagar	Revenue Dpt.	27°25'00"	77°05'60"	Pahari	Bharatpur	IIIb	1957	2010	6480	0	15	Yes
541	Pahari	Revenue Dpt.	27°42'38"	77°05'05"	Pahari	Bharatpur	IIIb	1957	2010	6480	0	24	Yes
0	Rajakhera *	WRD Stations	26°53'60"	78°10'60"	Rajakhera	Dhaulpur	IIIb	0	0	0	0	0	No
201	Rajakhera	Revenue Dpt.	26°53'60"	78°10'60"	Rajakhera	Dhaulpur	IIIb	0	0	0	0	0	No
453	Rajgarh	Revenue Dpt.	27°13'00"	76°37'00"	Rajgarh	Alwar	IIIb	0	0	0	0	0	No
249	Rajgarh	Revenue Dpt.	27°13'00"	76°37'00"	Rajgarh	Alwar	IIIb	1957	2010	6480	0	9	Yes
574	Mangalsar *	Revenue Dpt.	27°14'55"	76°24'11"	Rajgarh	Alwar	IIIb	0	0	0	0	0	No
514	Ramgarh	Revenue Dpt.	27°34'60"	76°49'00"	Ramgarh	Alwar	IIIb	0	0	0	0	0	No
248	Ramgarh	Revenue Dpt.	27°34'60"	76°49'00"	Ramgarh	Alwar	IIIb	1957	2010	6480	0	23	Yes
814	Roopwas *	WRD Stations	26°58'60"	77°34'00"	Rupbas	Bharatpur	IIIb	0	0	0	0	0	No
234	Rupwas	Revenue Dpt.	26°58'60"	77°34'00"	Rupbas	Bharatpur	IIIb	1957	2010	6480	1	31	Yes
197	Kalisil *	WRD Stations	26°15'48"	76°44'36"	Sapotra	Karauli	IIIb	1958	2010	6360	16	1043	Yes
198	Sapotra	Revenue Dpt.	26°17'30"	76°45'09"	Sapotra	Karauli	IIIb	1964	2010	5640	8	436	Yes
746	Mandrail	Revenue Dpt.	26°18'50"	77°14'20"	Sapotra	Karauli	IIIb	0	0	0	0	0	No
652	Bharatpur *	WRD Stations	27°14'11"	77°27'51"	Sewar	Bharatpur	IIIb	0	0	0	0	0	No
206	Ajan *	WRD Stations	27°09'57"	77°28'30"	Sewar	Bharatpur	IIIb	1959	2010	6240	3	160	Yes
208	Bharatpur	Revenue Dpt.	27°14'11"	77°27'51"	Sewar	Bharatpur	IIIb	1957	2010	6480	0	0	Yes
251	Thanagazi	Revenue Dpt.	27°25'00"	76°17'60"	Thanagazi	Alwar	IIIb	1957	2010	6480	0	15	Yes
260	Tijara	Revenue Dpt.	27°56'60"	76°50'60"	Tijara	Alwar	IIIb	1957	2010	6480	0	1	Yes
259	Tapukra	Revenue Dpt.	28°07'00"	76°49'00"	Tijara	Alwar	IIIb	1957	2010	6480	0	1	Yes
229	Toda Bhim	Revenue Dpt.	26°55'00"	76°49'00"	Todabhim	Karauli	IIIb	1957	2010	6480	1	86	Yes
863	Alwar *	WRD Stations	27°34'00"	76°35'60"	Umren	Alwar	IIIb	0	0	0	0	0	No
250	Siliserh *	WRD Stations	27°31'00"	76°31'60"	Umren	Alwar	IIIb	1965	2010	5520	8	444	Yes
243	Alwar	Revenue Dpt.	27°34'00"	76°35'60"	Umren	Alwar	IIIb	1957	2010	6480	0	9	Yes
247	Malakhera	Revenue Dpt.	27°23'29"	76°37'30"	Umren	Alwar	IIIb	1957	2010	6480	0	24	Yes
575	Jaisamand *	WRD Stations	27°29'18"	76°34'58"	Umren	Alwar	IIIb	0	0	0	0	0	No

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
211	Hingota *	WRD Stations	27°05'29"	77°02'16"	Weir	Bharatpur	IIIb	1967	2010	5280	2	106	Yes
210	Halena *	WRD Stations	27°07'00"	77°07'00"	Weir	Bharatpur	IIIb	1965	2010	5520	2	113	Yes
657	Bhusawar *	WRD Stations	27°01'58"	77°02'58"	Weir	Bharatpur	IIIb	0	0	0	0	0	No
0	Weir *	WRD Stations	27°01'05"	77°10'32"	Weir	Bharatpur	IIIb	0	0	0	0	0	No
444	Bikaner (A)	IMD Stations	28°00'00"	73°17'60"	Bikaner	Bikaner	Ic	1957	2001	5400	6	303	Yes
445	Bikaner	Revenue Dpt.	28°01'00"	73°17'60"	Bikaner	Bikaner	Ic	1957	2010	6480	0	1	Yes
675	Dungargarh	Revenue Dpt.	28°06'20"	74°00'30"	Dungargar	Bikaner	Ic	0	0	0	0	0	No
510	Jaisalmer (A)	IMD Stations	26°53'60"	70°55'00"	Jaisalmer	Jaisalmer	Ic	1957	2001	5400	6	347	Yes
511	Jaisalmer	Revenue Dpt.	26°53'60"	70°55'00"	Jaisalmer	Jaisalmer	Ic	1957	2010	6480	1	53	Yes
512	Nokh	Revenue Dpt.	27°33'38"	72°15'40"	Jaisalmer	Jaisalmer	Ic	0	0	0	0	0	No
798	Pugal	Revenue Dpt.	28°31'18"	72°47'40"	Khajuwala	Bikaner	Ic	0	0	0	0	0	No
716	Khajuwala	Revenue Dpt.	28°42'01"	72°35'36"	Khajuwala	Bikaner	Ic	0	0	0	0	0	No
662	Chatargarh	Revenue Dpt.	28°40'29"	73°07'04"	Khajuwala	Bikaner	Ic	0	0	0	0	0	No
447	Kolayat	Revenue Dpt.	27°49'22"	72°57'45"	Kolayat	Bikaner	Ic	1957	2010	6480	0	7	Yes
446	Lunkaransar	Revenue Dpt.	28°30'00"	73°45'00"	Lunkaransar	Bikaner	Ic	1957	2010	6480	0	0	Yes
449	Nokha	Revenue Dpt.	27°32'42"	73°28'54"	Nokha	Bikaner	Ic	1957	2010	6480	0	0	Yes
526	Surpura *	WRD Stations	27°42'32"	73°26'52"	Nokha	Bikaner	Ic	1958	2010	6360	11	723	Yes
454	Ratangarh	Revenue Dpt.	28°04'60"	74°37'00"	Ratangarh	Churu	Ic	0	0	0	0	0	No
515	Sam	Revenue Dpt.	26°49'60"	70°31'00"	Sam	Jaisalmer	Ic	0	0	0	0	0	No
509	Fatehgarh	Revenue Dpt.	26°29'50"	71°12'10"	Sam	Jaisalmer	Ic	0	0	0	0	0	No
513	Pokran	Revenue Dpt.	26°55'00"	71°55'60"	Sankra	Jaisalmer	Ic	0	0	0	0	0	No
455	Sardarshahar	Revenue Dpt.	28°25'60"	74°28'60"	Sardarshhar	Churu	Ic	0	0	0	0	0	No
456	Sujangarh	Revenue Dpt.	27°41'60"	74°28'60"	Sujangarh	Churu	Ic	1957	2010	6480	0	14	Yes
64	Mangrol	Revenue Dpt.	25°20'10"	76°30'56"	Antah	Baran	V	1957	2010	6480	0	8	Yes
43	Aata	Revenue Dpt.	25°09'10"	76°17'56"	Antah	Baran	V	0	0	0	0	0	No
59	Atru	Revenue Dpt.	24°52'10"	76°39'56"	Atru	Baran	V	1957	2010	6480	0	0	Yes
661	Chhapi Dam *	WRD Stations	24°20'35"	76°28'21"	Bakani	Jhalawar	V	0	0	0	0	0	No
32	Bakani	Revenue Dpt.	24°18'20"	76°13'56"	Bakani	Jhalawar	V	1957	2010	6480	1	38	Yes
647	Baran *	WRD Stations	25°06'09"	76°29'29"	Baran	Baran	V	0	0	0	0	0	No
60	Baran	Revenue Dpt.	25°06'09"	76°29'29"	Baran	Baran	V	1957	2010	6480	0	8	Yes
49	Gudha Dam *	WRD Stations	25°06'09"	76°29'29"	Baran	Baran	V	1968	2010	5160	12	602	Yes

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649	Bethli *	WRD Stations	24°37'14"	76°58'21"	Chhabra	Baran	V	0	0	0	0	0	No
61	Chhabra	Revenue Dpt.	24°40'01"	76°50'56"	Chhabra	Baran	V	1959	2010	6240	0	0	Yes
33	Bhimsagar *	WRD Stations	24°36'01"	76°31'56"	Chhipabarod	Baran	V	1968	2010	5160	13	659	Yes
62	Chhipabarod	Revenue Dpt.	24°37'01"	76°46'56"	Chhipabarod	Baran	V	1957	2010	6480	1	30	Yes
25	Gangdhar	Revenue Dpt.	23°56'02"	75°35'56"	Dag	Jhalawar	V	1957	2010	6480	0	8	Yes
34	Dug	Revenue Dpt.	23°56'02"	75°49'56"	Dag	Jhalawar	V	1957	2010	6480	1	40	Yes
162	Chandsen *	WRD Stations	25°21'10"	75°19'56"	Hindoli	Bundi	V	1968	2010	5160	6	297	Yes
860	Bundi *	WRD Stations	25°27'01"	75°37'56"	Hindoli	Bundi	V	0	0	0	0	0	No
48	Bundi	Revenue Dpt.	25°27'10"	75°37'56"	Hindoli	Bundi	V	1957	2010	6480	0	16	Yes
50	Hindoli	Revenue Dpt.	25°35'01"	75°29'56"	Hindoli	Bundi	V	1957	2010	6480	0	9	Yes
683	Gudha	Revenue Dpt.	25°29'22"	75°28'02"	Hindoli	Bundi	V	0	0	0	0	0	No
629	Abhaiypura *	WRD Stations	25°18'11"	75°26'49"	Hindoli	Bundi	V	0	0	0	0	0	No
65	Pipalda	Revenue Dpt.	25°34'01"	76°26'56"	Itawa	Kota	V	1957	2010	6480	0	1	Yes
653	Bhawani Mandi *	WRD Stations	24°24'56"	75°50'02"	Jhalrapatan	Jhalawar	V	0	0	0	0	0	No
42	Kalisindh *	WRD Stations	24°36'01"	76°09'56"	Jhalrapatan	Jhalawar	V	0	0	0	0	0	No
641	Asnawar *	WRD Stations	24°29'02"	76°20'56"	Jhalrapatan	Jhalawar	V	0	0	0	0	0	No
36	Jhalawar	Revenue Dpt.	24°32'02"	76°09'56"	Jhalrapatan	Jhalawar	V	1957	2010	6480	0	15	Yes
37	Jhalrapatan	Revenue Dpt.	24°33'02"	76°08'56"	Jhalrapatan	Jhalawar	V	1957	2010	6480	0	8	Yes
31	Asnawar	Revenue Dpt.	24°29'02"	76°20'56"	Jhalrapatan	Jhalawar	V	1957	2010	6480	4	237	Yes
40	Pachpahar	Revenue Dpt.	24°24'02"	75°49'56"	Jhalrapatan	Jhalawar	V	1957	2010	6480	0	0	Yes
1	Keshavrai Patan	Revenue Dpt.	25°18'01"	75°56'56"	Keshorai Patan	Bundi	V	0	0	0	0	0	No
57	Indergarh	Revenue Dpt.	25°43'01"	76°11'56"	Keshorai Patan	Bundi	V	0	0	0	0	0	No
45	Ramganjmandi	Revenue Dpt.	24°38'01"	75°55'56"	Khairabad	Kota	V	1957	2010	6480	0	8	Yes
707	Kanwas	Revenue Dpt.	24°52'07"	76°07'29"	Khairabad	Kota	V	0	0	0	0	0	No
663	Chechat	Revenue Dpt.	24°45'52"	75°53'18"	Khairabad	Kota	V	0	0	0	0	0	No
120	Khandar	Revenue Dpt.	26°10'00"	76°37'00"	Khandar	Sawai Madhopur	V	1957	2010	6480	0	0	Yes
21	Mansarowar *	WRD Stations	25°59'01"	76°29'56"	Khandar	Sawai Madhopur	V	1966	2010	5400	7	380	Yes
788	Pancholas *	WRD Stations	25°51'28"	76°15'49"	Khandar	Sawai Madhopur	V	0	0	0	0	0	No
38	Khanpur	Revenue Dpt.	24°44'10"	76°22'56"	Khanpur	Jhalawar	V	1957	2010	6480	0	8	Yes

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853	Bhanwargarh Colony *	WRD Stations	25°04'27"	76°48'10"	Kishanganj	Baran	V	0	0	0	0	0	No
66	Ummed Sagar *	WRD Stations	25°13'01"	76°46'56"	Kishanganj	Baran	V	1968	2010	5160	17	856	Yes
681	Gopalpura *	WRD Stations	25°09'53"	76°43'52"	Kishanganj	Baran	V	0	0	0	0	0	No
63	Kishanganj	Revenue Dpt.	25°06'10"	76°38'56"	Kishanganj	Baran	V	1957	2010	6480	0	0	Yes
17	Kota Barrage *	WRD Stations	25°11'01"	75°49'56"	Ladpur	Kota	V	1968	2010	5160	8	406	Yes
22	Alnia Dam *	WRD Stations	25°00'10"	75°52'44"	Ladpur	Kota	V	0	0	0	0	0	No
15	Kota A.P. (A)	IMD Stations	25°11'01"	75°50'56"	Ladpur	Kota	V	1964	2001	4560	9	426	Yes
26	Aklera	Revenue Dpt.	24°25'02"	76°33'56"	Manohar Thana	Jhalawar	V	1957	2010	6480	0	8	Yes
28	Manohar Thana	Revenue Dpt.	24°13'58"	76°48'21"	Manohar Thana	Jhalawar	V	0	0	0	0	0	No
671	Devpura *	WRD Stations	25°43'23"	75°59'38"	Nainwa	Bundi	V	0	0	0	0	0	No
51	Nainwa	Revenue Dpt.	25°48'01"	75°51'56"	Nainwa	Bundi	V	1957	2010	6480	0	9	Yes
39	Pirawa	Revenue Dpt.	24°09'39"	76°01'41"	Pirawa	Jhalawar	V	1957	2010	6480	0	0	Yes
838	Sunel	Revenue Dpt.	24°22'18"	75°57'33"	Pirawa	Jhalawar	V	0	0	0	0	0	No
0	Chanwali Dam *	WRD Stations	24°17'31"	76°09'33"	Pirawa	Jhalawar	V	0	0	0	0	0	No
825	Sawan Bhado *	WRD Stations	24°49'17"	76°05'47"	Sangod	Kota	V	0	0	0	0	0	No
46	Sangod	Revenue Dpt.	24°56'01"	76°16'56"	Sangod	Kota	V	1957	2010	6480	1	68	Yes
699	Dara *	WRD Stations	24°50'06"	76°00'24"	Sangod	Kota	V	0	0	0	0	0	No
178	Dheel *	WRD Stations	26°13'24"	76°07'03"	Sawai Madhopur	Sawai Madhopur	V	1966	2010	5400	6	298	Yes
121	Sawai Madhopur (A)	IMD Stations	26°01'22"	76°21'15"	Sawai Madhopur	Sawai Madhopur	V	0	0	0	0	0	No
122	Sawai Madhopur	Revenue Dpt.	26°01'22"	76°21'15"	Sawai Madhopur	Sawai Madhopur	V	1957	2010	6480	0	8	Yes
668	Choth Ka Barwara	Revenue Dpt.	26°03'01"	76°09'16"	Sawai Madhopur	Sawai Madhopur	V	0	0	0	0	0	No
67	Shahbad	Revenue Dpt.	25°15'01"	77°07'56"	Shahbad	Baran	V	0	0	0	0	0	No
12	Digod	Revenue Dpt.	25°13'01"	76°04'56"	Sultanpura	Kota	V	1957	2010	6480	1	46	Yes
0	Gararda *	WRD Stations	25°14'37"	75°41'42"	Talera	Bundi	V	0	0	0	0	0	No
695	Jawahar Sagar *	WRD Stations	25°02'10"	75°40'08"	Talera	Bundi	V	0	0	0	0	0	No
636	Vardha Dam *	WRD Stations	25°14'37"	75°41'42"	Talera	Bundi	V	0	0	0	0	0	No
19	Ladpura	Revenue Dpt.	25°08'01"	75°41'56"	Talera	Bundi	V	1957	2010	6480	0	8	Yes
52	Talera	Revenue Dpt.	25°20'01"	75°42'56"	Talera	Bundi	V	1957	2010	6480	0	8	Yes

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659	Chanda Ka Talab *	WRD Stations	25°15'11"	75°36'55"	Talera	Bundi	V	0	0	0	0	0	No
744	Malsisar	Revenue Dpt.	28°21'09"	75°17'30"	Alsisar	Jhunjhunun	IIa	0	0	0	0	0	No
854	Buhana	Revenue Dpt.	28°12'28"	75°52'38"	Buhana	Jhunjhunun	IIa	0	0	0	0	0	No
435	Chirawa	Revenue Dpt.	28°13'60"	75°39'00"	Chirawa	Jhunjhunun	IIa	1957	2010	6480	0	0	Yes
450	Churu (A)	IMD Stations	28°18'00"	74°58'00"	Churu	Churu	IIa	1957	2001	5400	5	270	Yes
451	Churu	Revenue Dpt.	28°18'00"	74°58'00"	Churu	Churu	IIa	1957	2010	6480	1	48	Yes
433	Ramgarh Shethan	Revenue Dpt.	27°13'60"	75°12'00"	Danta Ramgarh	Sikar	IIa	1957	2010	6480	2	142	Yes
432	Dantaramgarh	Revenue Dpt.	27°15'00"	75°12'00"	Danta Ramgarh	Sikar	IIa	1957	2010	6480	0	7	Yes
689	Harsor *	WRD Stations	26°44'12"	74°28'56"	Degana	Nagaur	IIa	0	0	0	0	0	No
339	Degana	Revenue Dpt.	26°53'60"	74°19'00"	Degana	Nagaur	IIa	1957	2010	6480	0	15	Yes
527	Didwana	Revenue Dpt.	27°23'60"	74°34'60"	Didwana	Nagaur	IIa	0	0	0	0	0	No
532	Fatehpur	Revenue Dpt.	27°58'60"	74°58'00"	Fatehpur	Sikar	IIa	1957	2010	6480	0	22	Yes
528	Jayal	Revenue Dpt.	27°13'13"	74°10'55"	Jayal	Nagaur	IIa	0	0	0	0	0	No
436	Jhunjhunu	Revenue Dpt.	28°07'60"	75°22'60"	Jhunjhunu	Jhunjhunun	IIa	1957	2010	6480	1	41	Yes
420	Khetri	Revenue Dpt.	28°00'03"	75°47'17"	Khetri	Jhunjhunun	IIa	1957	2010	6480	0	8	Yes
430	Nawa	Revenue Dpt.	27°01'00"	75°00'60"	Kuchaman City	Nagaur	IIa	1957	2010	6480	0	8	Yes
533	Laxmangarh	Revenue Dpt.	27°49'60"	75°01'60"	Lachhmangarh	Sikar	IIa	1957	2010	6480	0	15	Yes
529	Ladnu	Revenue Dpt.	27°38'60"	74°22'60"	Ladnu	Nagaur	IIa	1957	2010	6480	0	0	Yes
741	Makrana	Revenue Dpt.	27°02'20"	74°43'54"	Makrana	Nagaur	IIa	0	0	0	0	0	No
340	Merta City	Revenue Dpt.	26°37'60"	74°01'60"	Merta	Nagaur	IIa	0	0	0	0	0	No
719	Kheevsar	Revenue Dpt.	26°58'45"	73°24'38"	Mundwa	Nagaur	IIa	0	0	0	0	0	No
531	Nagaur	Revenue Dpt.	27°11'60"	73°45'00"	Nagaur	Nagaur	IIa	0	0	0	0	0	No
782	Nawalgarh	Revenue Dpt.	27°51'00"	75°16'12"	Nawalgarh	Jhunjhunun	IIa	0	0	0	0	0	No
803	Raipur Patan *	Revenue Dpt.	27°45'29"	75°58'01"	Neem Ka Thana	Sikar	IIa	0	0	0	0	0	No
421	Neem Ka Thana	Revenue Dpt.	27°43'60"	75°46'60"	Neem Ka Thana	Sikar	IIa	1957	2010	6480	0	7	Yes
431	Parbatsar	Revenue Dpt.	26°52'00"	74°45'60"	Parbatsar	Nagaur	IIa	1957	2010	6480	0	8	Yes
534	Sikar *	WRD Stations	27°37'00"	75°07'60"	Piprali	Sikar	IIa	1957	2001	5400	5	271	Yes
535	Sikar	Revenue Dpt.	27°37'00"	75°07'60"	Piprali	Sikar	IIa	1957	2010	6480	1	38	Yes
434	Srimadhopur	Revenue Dpt.	27°26'16"	75°36'01"	Srimadhopur	Sikar	IIa	0	0	0	0	0	No
437	Pilani (A)	Imd Stations	28°21'00"	75°35'60"	Surajgarh	Jhunjhunun	IIa	1959	2002	5280	6	304	Yes

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457	Taranagar	Revenue Dpt.	28°40'00"	75°01'60"	Taranagar	Churu	IIa	0	0	0	0	0	No
422	Udaipur Wati	Revenue Dpt.	27°43'22"	75°28'08"	Udaipurwati	Jhunjhunun	IIa	1957	2010	6480	1	47	Yes
3	Arnod	Revenue Dpt.	23°53'00"	74°45'00"	Arnod	Pratapgarh	IVb	1968	2010	5160	2	104	Yes
290	Aspur	Revenue Dpt.	23°56'60"	74°05'00"	Aspur	Dungarpur	IVb	1957	2010	6480	0	8	Yes
297	Sabla	Revenue Dpt.	23°51'00"	74°12'00"	Aspur	Dungarpur	IVb	1957	2010	6480	1	31	Yes
296	Nithawa	Revenue Dpt.	23°55'00"	74°17'60"	Aspur	Dungarpur	IVb	1957	2010	6480	0	1	Yes
833	Som Kamla Amba *	WRD Stations	23°58'19"	74°01'29"	Aspur	Dungarpur	IVb	0	0	0	0	0	No
30	Shergarh *	WRD Stations	23°19'60"	74°10'00"	Bagidora	Banswara	IVb	0	0	0	0	0	No
525	Shergarh	Revenue Dpt.	23°19'60"	74°10'00"	Bagidora	Banswara	IVb	0	0	0	0	0	No
314	Shergarh	Revenue Dpt.	23°19'60"	74°10'00"	Bagidora	Banswara	IVb	1957	2010	6480	1	75	Yes
310	Bagidora	Revenue Dpt.	23°25'00"	74°17'60"	Bagidora	Banswara	IVb	1967	2010	5280	1	30	Yes
265	Banswara (A)	IMD Stations	23°33'37"	74°26'31"	Banswara	Banswara	IVb	1965	2001	4440	6	280	Yes
266	Banswara	Revenue Dpt.	23°33'37"	74°26'31"	Banswara	Banswara	IVb	1957	2010	6480	0	0	Yes
715	Kesarpura	Revenue Dpt.	23°29'27"	74°30'35"	Banswara	Banswara	IVb	0	0	0	0	0	No
294	Dungarpur	Revenue Dpt.	23°51'00"	73°43'00"	Bichhiwara	Dungarpur	IVb	1957	2010	6480	0	0	Yes
323	Kanba	Revenue Dpt.	23°48'51"	73°34'09"	Bichhiwara	Dungarpur	IVb	1957	2010	6480	0	7	Yes
292	Dewal	Revenue Dpt.	23°55'60"	73°42'00"	Bichhiwara	Dungarpur	IVb	1957	2010	6480	0	16	Yes
324	Veejan	Revenue Dpt.	23°42'10"	73°42'46"	Bichhiwara	Dungarpur	IVb	0	0	0	0	0	No
268	Danpur	Revenue Dpt.	23°31'00"	74°43'60"	Chhoti Sarvan	Banswara	IVb	1957	2010	6480	2	122	Yes
287	Dhariawad *	WRD Stations	24°06'08"	74°26'35"	Dhariawad	Pratapgarh	IVb	0	0	0	0	0	No
288	Dhariawad	Revenue Dpt.	24°06'00"	74°26'58"	Dhariawad	Pratapgarh	IVb	1961	2010	6000	2	136	Yes
295	Ganeshpur	Revenue Dpt.	23°55'00"	73°54'60"	Dungarpur	Dungarpur	IVb	1957	2010	6480	0	9	Yes
264	Arthuna	Revenue Dpt.	23°30'00"	74°05'00"	Garhi	Banswara	IVb	1957	2010	6480	0	0	Yes
269	Garhi	Revenue Dpt.	23°36'00"	74°07'60"	Garhi	Banswara	IVb	1957	2010	6480	0	0	Yes
273	Loharia	Revenue Dpt.	23°46'00"	74°13'60"	Ghatol	Banswara	IVb	1957	2010	6480	1	30	Yes
270	Ghatol	Revenue Dpt.	23°46'00"	74°24'60"	Ghatol	Banswara	IVb	1957	2010	6480	0	0	Yes
267	Bhungra	Revenue Dpt.	23°40'60"	74°30'60"	Ghatol	Banswara	IVb	1957	2010	6480	1	38	Yes
271	Jagpura	Revenue Dpt.	23°52'00"	74°20'60"	Ghatol	Banswara	IVb	1957	2010	6480	0	15	Yes
312	Kushalgarh	Revenue Dpt.	23°12'29"	74°26'04"	Kushalgarh	Banswara	IVb	1957	2010	6480	0	7	Yes
735	Lasadiya	Revenue Dpt.	24°15'37"	74°14'37"	Lasadiya	Udaipur	IVb	0	0	0	0	0	No
274	Mahi Dam *	WRD Stations	23°37'60"	74°33'07"	Peepalkhoont	Pratapgarh	IVb	1966	2010	5400	10	537	Yes

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275	Pipalkhunt	Revenue Dpt.	23°46'60"	74°35'00"	Peepalkhoont	Pratapgarh	IVb	1968	2007	4800	0	0	Yes
309	Sagwara	Revenue Dpt.	23°41'00"	74°01'60"	Sagwara	Dungarpur	IVb	1957	2010	6480	0	0	Yes
820	Sajjangarh	Revenue Dpt.	23°15'33"	74°17'23"	Sajjangarh	Banswara	IVb	1957	2010	6480	1	38	Yes
848	Salumber *	WRD Stations	24°01'60"	74°12'00"	Salumbar	Udaipur	IVb	0	0	0	0	0	No
305	Salumber	Revenue Dpt.	24°01'60"	74°12'00"	Salumbar	Udaipur	IVb	1957	2010	6480	0	8	Yes
737	Madar *	WRD Stations	24°04'55"	74°10'55"	Salumbar	Udaipur	IVb	0	0	0	0	0	No
308	Galiakot	Revenue Dpt.	23°33'00"	74°00'00"	Simalwara	Dungarpur	IVb	1957	2010	6480	0	1	Yes
545	Cheekhly	Revenue Dpt.	23°25'51"	73°57'14"	Simalwara	Dungarpur	IVb	0	0	0	0	0	No
322	Dhambola	Revenue Dpt.	23°36'00"	73°46'00"	Simalwara	Dungarpur	IVb	1957	2010	6480	0	0	Yes
484	Longwala *	WRD Stations	29°33'29"	74°05'44"	Anupgarh	Ganganagar	Ib	1959	2010	6240	17	1068	Yes
458	Anupgarh	Revenue Dpt.	29°11'07"	73°12'51"	Anupgarh	Ganganagar	Ib	1957	2010	6480	0	16	Yes
634	Shri Vijaynagar	Revenue Dpt.	29°14'26"	73°31'03"	Anupgarh	Ganganagar	Ib	0	0	0	0	0	No
507	T.A. Singh *	WRD Stations	29°11'41"	74°51'09"	Bhadra	Hanumangarh	Ib	1957	2010	6480	9	587	Yes
464	Chhani *	WRD Stations	29°11'20"	75°19'42"	Bhadra	Hanumangarh	Ib	0	0	0	0	0	No
460	Bhadra	Revenue Dpt.	29°07'26"	75°10'00"	Bhadra	Hanumangarh	Ib	1957	2010	6480	2	135	Yes
470	Ganganagar (A)	IMD Stations	29°55'00"	73°52'60"	Ganganagar	Ganganagar	Ib	1957	2001	5400	6	309	Yes
471	Ganganagar	Revenue Dpt.	29°55'00"	73°52'60"	Ganganagar	Ganganagar	Ib	1957	2010	6480	1	46	Yes
678	Ghadsana	Revenue Dpt.	29°01'18"	73°04'44"	Ghadsana	Ganganagar	Ib	0	0	0	0	0	No
475	Hanumangarh	Revenue Dpt.	29°34'60"	74°19'00"	Hanumangarh	Hanumangarh	Ib	1957	2010	6480	2	127	Yes
481	Srikaranpur	Revenue Dpt.	29°50'53"	73°27'06"	Karanpur	Ganganagar	Ib	1957	2010	6480	0	24	Yes
487	Nohar	Revenue Dpt.	29°10'60"	74°46'00"	Nohar	Hanumangarh	Ib	0	0	0	0	0	No
490	Padampur	Revenue Dpt.	29°42'10"	73°37'43"	Padampur	Ganganagar	Ib	1957	2010	6480	0	17	Yes
492	Pilibanga	Revenue Dpt.	29°26'60"	74°04'00"	Pilibanga	Hanumangarh	Ib	1957	2010	6480	4	288	Yes
687	Hanslia *	WRD Stations	29°34'32"	74°02'47"	Pilibanga	Hanumangarh	Ib	0	0	0	0	0	No
495	Raisinghnagar	Revenue Dpt.	29°31'60"	73°27'00"	Raisinghnagar	Ganganagar	Ib	1957	2010	6480	0	24	Yes
466	Dabla	Revenue Dpt.	29°27'55"	73°38'03"	Raisinghnagar	Ganganagar	Ib	1959	2010	6240	12	739	Yes
809	Rawatsar	Revenue Dpt.	29°16'03"	74°24'16"	Rawatsar	Hanumangarh	Ib	0	0	0	0	0	No
496	Sadulshahar	Revenue Dpt.	29°53'60"	74°10'00"	Sadulshahar	Ganganagar	Ib	1957	2010	6480	0	24	Yes
467	Dhaban *	WRD Stations	29°52'55"	74°30'53"	Sangariya	Hanumangarh	Ib	1958	2010	6360	13	797	Yes
497	Sangriya	Revenue Dpt.	29°47'52"	74°27'41"	Sangariya	Hanumangarh	Ib	1957	2010	6480	2	129	Yes
822	Santpura *	WRD Stations	29°54'02"	74°24'47"	Sangariya	Hanumangarh	Ib	0	0	0	0	0	No

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502	Suratgarh	Revenue Dpt.	29°19'00"	73°54'00"	Suratgarh	Ganganagar	Ib	1957	2010	6480	1	38	Yes
504	Sunderpura *	WRD Stations	29°47'56"	74°05'14"	Tibi	Hanumangarh	Ib	1966	2010	5400	16	845	Yes
508	Tibbi	Revenue Dpt.	29°31'60"	74°30'00"	Tibi	Hanumangarh	Ib	1959	2010	6240	3	176	Yes
376	Bankli *	WRD Stations	25°42'37"	72°52'43"	Ahore	Jalore	IIb	0	0	0	0	0	No
561	Bali	Revenue Dpt.	25°10'60"	73°16'60"	Bali	Pali	IIb	1957	2010	6480	0	8	Yes
721	Kot *	WRD Stations	25°11'31"	73°20'04"	Bali	Pali	IIb	0	0	0	0	0	No
642	Bagoda	Revenue Dpt.	25°13'10"	72°01'03"	Bhinmal	Jalore	IIb	0	0	0	0	0	No
538	Bhopal Garh	Revenue Dpt.	26°38'45"	73°29'35"	Bhopalgarh	Jodhpur	IIb	0	0	0	0	0	No
353	Jaswant Sagar *	WRD Stations	26°13'28"	73°41'21"	Bilara	Jodhpur	IIb	1957	2010	6480	4	237	Yes
698	Jaliwada *	WRD Stations	26°24'48"	73°35'59"	Bilara	Jodhpur	IIb	0	0	0	0	0	No
355	Bilara	Revenue Dpt.	26°10'60"	73°42'00"	Bilara	Jodhpur	IIb	1957	2010	6480	0	16	Yes
382	Sadri *	WRD Stations	25°07'00"	73°28'00"	Desuri	Pali	IIb	1957	2010	6480	11	718	Yes
380	Muthana *	WRD Stations	25°13'60"	73°28'00"	Desuri	Pali	IIb	1964	2010	5640	14	807	Yes
379	Kana *	WRD Stations	25°15'49"	73°30'46"	Desuri	Pali	IIb	1962	2010	5880	16	922	Yes
374	Desuri	Revenue Dpt.	25°16'14"	73°35'24"	Desuri	Pali	IIb	1957	2010	6480	0	16	Yes
348	Jaitaran	Revenue Dpt.	26°11'60"	73°57'00"	Jaitaran	Pali	IIb	1957	2010	6480	0	16	Yes
543	Jalore	Revenue Dpt.	25°30'00"	72°37'00"	Jalore	Jalore	IIb	1957	2010	6480	0	0	Yes
544	Raniwara	Revenue Dpt.	25°12'11"	72°27'41"	Jalore	Jalore	IIb	0	0	0	0	0	No
391	Ahore	Revenue Dpt.	25°23'00"	72°46'00"	Jalore	Jalore	IIb	1957	2010	6480	0	23	Yes
415	Bhinmal	Revenue Dpt.	25°00'60"	72°16'00"	Jaswantpura	Jalore	IIb	0	0	0	0	0	No
413	Jaswantpura	Revenue Dpt.	24°48'00"	72°28'00"	Jaswantpura	Jalore	IIb	1957	2010	6480	2	120	Yes
560	Phulada *	WRD Stations	25°37'23"	73°49'16"	Marwar Junction	Pali	IIb	0	0	0	0	0	No
365	Jograwas *	WRD Stations	25°46'07"	73°34'06"	Marwar Junction	Pali	IIb	1962	2010	5880	18	1036	Yes
562	Marwar Junct	Revenue Dpt.	25°43'31"	73°36'34"	Marwar Junction	Pali	IIb	0	0	0	0	0	No
557	Sirimari *	WRD Stations	25°40'32"	73°48'43"	Marwar Junction	Pali	IIb	0	0	0	0	0	No
706	Kantalia *	WRD Stations	25°47'22"	73°49'53"	Marwar Junction	Pali	IIb	0	0	0	0	0	No
371	Hemawas *	WRD Stations	25°44'08"	73°22'58"	Pali	Pali	IIb	1958	2010	6360	8	509	Yes

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363	Baniawas *	WRD Stations	25°46'00"	73°31'00"	Pali	Pali	IIb	1964	2010	5640	10	541	Yes
372	Pali	Revenue Dpt.	25°46'13"	73°19'42"	Pali	Pali	IIb	1957	2010	6480	1	38	Yes
700	Gajnai	Revenue Dpt.	25°52'60"	73°58'32"	Pali	Pali	IIb	0	0	0	0	0	No
360	Raipur Luni *	WRD Stations	26°03'00"	74°01'60"	Raipur	Pali	IIb	1966	2010	5400	10	556	Yes
341	Girinanda *	WRD Stations	26°10'60"	74°10'60"	Raipur	Pali	IIb	1957	2010	6480	9	586	Yes
802	Raipur *	WRD Stations	26°03'00"	74°01'60"	Raipur	Pali	IIb	0	0	0	0	0	No
359	Raipur	Revenue Dpt.	26°03'00"	74°01'60"	Raipur	Pali	IIb	1957	2010	6480	0	16	Yes
714	Ker Bundh *	WRD Stations	24°45'46"	72°19'01"	Raniwara	Jalore	IIb	0	0	0	0	0	No
548	Reodhar *	WRD Stations	24°37'00"	72°31'60"	Reodar	Sirohi	IIb	1957	2010	6480	0	0	Yes
375	Kharda *	WRD Stations	25°55'00"	73°14'00"	Rohat	Pali	IIb	1958	2010	6360	9	555	Yes
563	Giroliya *	WRD Stations	25°46'10"	73°02'46"	Rohat	Pali	IIb	0	0	0	0	0	No
813	Rohat	Revenue Dpt.	25°57'22"	73°08'21"	Rohat	Pali	IIb	0	0	0	0	0	No
352	Sanchore	Revenue Dpt.	24°44'58"	71°45'51"	Sanchore	Jalore	IIb	0	0	0	0	0	No
826	Sayala	Revenue Dpt.	25°19'27"	72°21'39"	Sayla	Jalore	IIb	0	0	0	0	0	No
547	Sheoganj *	WRD Stations	25°08'22"	73°04'04"	Sheoganj	Sirohi	IIb	1957	2010	6480	1	30	Yes
410	Ora *	WRD Stations	25°01'00"	72°47'60"	Sirohi	Sirohi	IIb	1957	2010	6480	10	633	Yes
411	Sirohi	Revenue Dpt.	24°52'60"	72°52'00"	Sirohi	Sirohi	IIb	1957	2010	6480	0	0	Yes
409	Danta *	WRD Stations	24°48'00"	72°50'60"	Sirohi	Sirohi	IIb	1961	2010	6000	10	569	Yes
550	Angore *	WRD Stations	24°48'00"	72°48'53"	Sirohi	Sirohi	IIb	0	0	0	0	0	No
349	Meli Tank *	WRD Stations	25°45'00"	72°28'00"	Siwana	Barmer	IIb	1957	2010	6480	8	518	Yes
351	Siwana	Revenue Dpt.	25°38'60"	72°24'60"	Siwana	Barmer	IIb	1957	2010	6480	0	7	Yes
361	Sardar Samand *	WRD Stations	25°58'56"	73°22'58"	Sojat	Pali	IIb	1957	2010	6480	9	554	Yes
805	Raisagar Chopra *	WRD Stations	26°03'00"	73°24'60"	Sojat	Pali	IIb	0	0	0	0	0	No
362	Sojat	Revenue Dpt.	25°55'56"	73°39'18"	Sojat	Pali	IIb	1957	2010	6480	0	8	Yes
696	Jawai Dam *	WRD Stations	25°06'10"	73°08'53"	Sumerpur	Pali	IIb	0	0	0	0	0	No
837	Sumerpur	Revenue Dpt.	25°09'16"	73°04'55"	Sumerpur	Pali	IIb	0	0	0	0	0	No
389	Takhatgarh *	WRD Stations	25°19'00"	73°01'00"	Sumerpur	Pali	IIb	1957	2010	6480	13	838	Yes
388	Sanderao *	WRD Stations	25°20'18"	73°11'11"	Sumerpur	Pali	IIb	1958	2001	5280	16	856	Yes
556	Mithri *	WRD Stations	25°20'18"	73°11'11"	Sumerpur	Pali	IIb	0	0	0	0	0	No
516	Biran *	WRD Stations	26°28'34"	72°40'16"	Balesar	Jodhpur	Ia	0	0	0	0	0	No
350	Pachpadra	Revenue Dpt.	25°55'60"	72°16'00"	Balotra	Barmer	Ia	1957	2010	6480	0	24	Yes

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354	Balotra	Revenue Dpt.	25°49'60"	72°15'00"	Balotra	Barmer	Ia	1957	2002	5520	13	703	Yes
438	Barmer (A)	IMD Stations	25°45'23"	71°24'03"	Barmer	Barmer	Ia	1957	2002	5520	6	319	Yes
439	Barmer	Revenue Dpt.	25°45'23"	71°24'03"	Barmer	Barmer	Ia	1957	2010	6480	0	17	Yes
808	Ramsar	Revenue Dpt.	25°43'47"	70°52'43"	Barmer	Barmer	Ia	0	0	0	0	0	No
440	Baitu	Revenue Dpt.	25°53'48"	71°46'58"	Baytoo	Barmer	Ia	0	0	0	0	0	No
441	Chohtan	Revenue Dpt.	25°28'60"	71°04'00"	Chohtan	Barmer	Ia	0	0	0	0	0	No
0	Sendwa	Revenue Dpt.	25°04'26"	71°09'42"	Chohtan	Barmer	Ia	0	0	0	0	0	No
684	Gudhamalani	Revenue Dpt.	25°11'33"	71°43'07"	Dhorimanna	Barmer	Ia	0	0	0	0	0	No
0	Dhorimanna	Revenue Dpt.	25°12'21"	71°26'26"	Dhorimanna	Barmer	Ia	0	0	0	0	0	No
736	Luni	Revenue Dpt.	25°59'46"	73°00'40"	Luni	Jodhpur	Ia	0	0	0	0	0	No
520	Jodhpur *	WRD Stations	26°18'00"	73°01'00"	Mandor	Jodhpur	Ia	1957	2010	6480	0	8	Yes
752	Dantiwada *	WRD Stations	26°16'40"	73°19'43"	Mandor	Jodhpur	Ia	0	0	0	0	0	No
519	Jodhpur City (A)	IMD Stations	26°18'00"	73°01'60"	Mandor	Jodhpur	Ia	0	0	0	0	0	No
518	Jodhpur	Revenue Dpt.	26°18'00"	73°01'60"	Mandor	Jodhpur	Ia	1957	2001	5400	5	288	Yes
711	Karodi Dhwaj *	WRD Stations	26°37'07"	72°40'06"	Osian	Jodhpur	Ia	0	0	0	0	0	No
536	Osian	Revenue Dpt.	26°43'00"	72°55'00"	Osian	Jodhpur	Ia	1957	2010	6480	0	16	Yes
523	Phalodi (A)	IMD Stations	27°07'60"	72°22'00"	Phalodi	Jodhpur	Ia	1957	2001	5400	7	393	Yes
524	Phalodi	Revenue Dpt.	27°07'60"	72°22'00"	Phalodi	Jodhpur	Ia	1957	2010	6480	0	15	Yes
443	Sheo	Revenue Dpt.	26°10'60"	71°15'00"	Sheo	Barmer	Ia	1957	2010	6480	0	14	Yes
0	Gadararoad	Revenue Dpt.	25°44'34"	70°39'00"	Sheo	Barmer	Ia	0	0	0	0	0	No
638	Sindhari	Revenue Dpt.	25°33'54"	71°55'21"	Sindhari	Barmer	Ia	0	0	0	0	0	No
183	Jaipur *	WRD Stations	26°54'49"	75°47'04"	Amber	Jaipur	IIIa	0	0	0	0	0	No
185	Jaipur (A)	IMD Stations	26°48'55"	75°46'60"	Amber	Jaipur	IIIa	1957	2001	5400	7	360	Yes
184	Jaipur	Revenue Dpt.	26°54'49"	75°47'04"	Amber	Jaipur	IIIa	1957	2010	6480	1	53	Yes
190	Sanganer	Revenue Dpt.	26°48'55"	75°46'60"	Amber	Jaipur	IIIa	1957	2010	6480	0	22	Yes
426	Chomu	Revenue Dpt.	27°10'00"	75°39'60"	Amber	Jaipur	IIIa	1961	2010	6000	0	14	Yes
180	Amber	Revenue Dpt.	26°58'60"	75°52'00"	Amber	Jaipur	IIIa	1957	2010	6480	0	22	Yes
0	Sarwar Thana *	WRD Stations	26°03'54"	75°01'14"	Arain	Ajmer	IIIa	0	0	0	0	0	No
154	Arain	Revenue Dpt.	26°26'59"	75°02'44"	Arain	Ajmer	IIIa	1958	2010	6360	1	62	Yes
160	Sarwar	Revenue Dpt.	26°03'54"	75°01'14"	Arain	Ajmer	IIIa	1958	2010	6360	1	37	Yes
0	Baswa *	WRD Stations	27°08'60"	76°35'00"	Bandikui	Dausa	IIIa	0	0	0	0	0	No

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645	Bandikui *	WRD Stations	26°59'54"	76°34'07"	Bandikui	Dausa	IIIa	0	0	0	0	0	No
220	Baswa	Revenue Dpt.	27°08'60"	76°35'00"	Bandikui	Dausa	IIIa	1957	2010	6480	1	30	Yes
800	Raidia Dam *	WRD Stations	27°07'03"	76°24'41"	Bandikui	Dausa	IIIa	0	0	0	0	0	No
181	Bassi	Revenue Dpt.	26°50'07"	76°03'04"	Bassi	Jaipur	IIIa	1959	2010	6240	0	22	Yes
155	Bhinai	Revenue Dpt.	26°03'06"	74°46'18"	Binay	Ajmer	IIIa	1957	2010	6480	2	94	Yes
157	Goela	Revenue Dpt.	26°07'18"	74°56'51"	Binay	Ajmer	IIIa	1957	2010	6480	7	419	Yes
182	Chaksu	Revenue Dpt.	26°36'21"	75°56'44"	Chaksu	Jaipur	IIIa	1957	2010	6480	0	0	Yes
221	Dausa	Revenue Dpt.	26°53'60"	76°20'00"	Dausa	Dausa	IIIa	1957	2010	6480	0	9	Yes
658	Bisalpur Dam *	WRD Stations	25°45'55"	75°23'16"	Deoli	Tonk	IIIa	0	0	0	0	0	No
127	Moti Sagar *	WRD Stations	25°55'00"	75°39'60"	Deoli	Tonk	IIIa	1963	2010	5760	5	272	Yes
130	Panwar Sagar *	WRD Stations	25°45'00"	75°30'00"	Deoli	Tonk	IIIa	1963	2010	5760	7	417	Yes
128	Nasirda *	WRD Stations	25°56'41"	75°22'05"	Deoli	Tonk	IIIa	1963	2010	5760	6	333	Yes
165	Chhaparwara *	WRD Stations	26°37'39"	75°15'53"	Dudu	Jaipur	IIIa	1966	2010	5400	10	556	Yes
0	Naraina *	WRD Stations	26°47'30"	75°12'19"	Dudu	Jaipur	IIIa	0	0	0	0	0	No
0	Mojamabad	Revenue Dpt.	26°40'21"	75°21'37"	Dudu	Jaipur	IIIa	0	0	0	0	0	No
427	Phulera	Revenue Dpt.	26°52'60"	75°13'60"	Dudu	Jaipur	IIIa	1957	2010	6480	1	71	Yes
171	Naraina	Revenue Dpt.	26°47'30"	75°12'19"	Dudu	Jaipur	IIIa	1959	2010	6240	1	46	Yes
553	Sainthal Sagar *	WRD Stations	27°01'50"	76°15'38"	Jamwa Ramgarh	Jaipur	IIIa	0	0	0	0	0	No
225	Ramgarh *	WRD Stations	27°02'43"	76°03'34"	Jamwa Ramgarh	Jaipur	IIIa	0	0	0	0	0	No
222	Jamwa Ramgarh	Revenue Dpt.	27°02'43"	76°03'34"	Jamwa Ramgarh	Jaipur	IIIa	1957	2010	6480	0	23	Yes
343	Beawar *	WRD Stations	26°06'00"	74°19'00"	Jawaja	Ajmer	IIIa	1957	2010	6480	1	38	Yes
0	Beawar	Revenue Dpt.	26°06'00"	74°19'00"	Jawaja	Ajmer	IIIa	0	0	0	0	0	No
186	Kanota *	WRD Stations	26°52'33"	75°56'34"	Jhotwara	Jaipur	IIIa	1961	2010	6000	3	162	Yes
135	Kekri	Revenue Dpt.	25°58'00"	75°09'00"	Kekri	Ajmer	IIIa	1957	2010	6480	1	45	Yes
630	Bandrasindri *	WRD Stations	26°35'56"	75°02'14"	Kishangarh	Ajmer	IIIa	0	0	0	0	0	No
262	Kotputli	Revenue Dpt.	27°43'00"	76°13'00"	Kotputli	Jaipur	IIIa	1957	2010	6480	1	60	Yes
841	Taskola *	WRD Stations	27°35'35"	76°01'30"	Kotputli	Jaipur	IIIa	0	0	0	0	0	No
0	Lalsot *	WRD Stations	26°33'39"	76°19'31"	Lalsot	Dausa	IIIa	0	0	0	0	0	No
188	Rahuwas *	WRD Stations	26°41'59"	76°20'08"	Lalsot	Dausa	IIIa	1966	2010	5400	11	587	Yes

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187	Lalsot	Revenue Dpt.	26°33'39"	76°19'31"	Lalsot	Dausa	IIIa	1957	2010	6480	0	24	Yes
164	Tordi Sagar*	WRD Stations	26°12'32"	75°25'07"	Malpura	Tonk	IIIa	1963	2010	5760	7	403	Yes
175	Malpura	Revenue Dpt.	26°17'44"	75°22'34"	Malpura	Tonk	IIIa	1957	2010	6480	0	8	Yes
776	Nagar Fort	Revenue Dpt.	26°27'52"	75°12'13"	Malpura	Tonk	IIIa	0	0	0	0	0	No
163	Lamba Hari Singh *	WRD Stations	26°18'17"	75°09'42"	Malpura	Tonk	IIIa	1968	2010	5160	8	426	Yes
780	Narayan Sagar *	WRD Stations	25°55'52"	74°33'15"	Masooda	Ajmer	IIIa	0	0	0	0	0	No
136	Masuda	Revenue Dpt.	26°07'00"	74°31'60"	Masooda	Ajmer	IIIa	1963	2010	5760	1	53	Yes
816	Rupangarh *	WRD Stations	26°47'41"	74°51'08"	Masooda	Ajmer	IIIa	0	0	0	0	0	No
0	Niwai *	WRD Stations	26°21'43"	75°55'38"	Niwai	Tonk	IIIa	0	0	0	0	0	No
179	Niwai	Revenue Dpt.	26°21'48"	75°55'38"	Niwai	Tonk	IIIa	1957	2010	6480	0	8	Yes
176	Mashi *	WRD Stations	26°22'60"	75°45'60"	Niwai	Tonk	IIIa	1967	2010	5280	2	124	Yes
159	Nasira Bad	Revenue Dpt.	26°17'49"	74°44'12"	Peesangan	Ajmer	IIIa	1957	2010	6480	1	45	Yes
423	Ajmer (A)	IMD Stations	26°28'31"	74°39'13"	Peesangan	Ajmer	IIIa	1957	1999	5160	4	188	Yes
424	Ajmer	Revenue Dpt.	26°28'31"	74°39'13"	Peesangan	Ajmer	IIIa	1957	2010	6480	6	376	Yes
346	Pushkar	Revenue Dpt.	26°28'60"	74°32'60"	Peesangan	Ajmer	IIIa	1957	2010	6480	0	15	Yes
345	Pisangan	Revenue Dpt.	26°23'60"	74°30'00"	Peesangan	Ajmer	IIIa	1957	2010	6480	1	77	Yes
344	Mangliawas	Revenue Dpt.	26°16'60"	74°30'00"	Peesangan	Ajmer	IIIa	1957	2010	6480	1	60	Yes
0	Phutiya *	WRD Stations	25°13'41"	73°12'47"	Peesangan	Ajmer	IIIa	0	0	0	0	0	No
682	Govindgarh *	WRD Stations	26°27'10"	74°22'56"	Peesangan	Ajmer	IIIa	0	0	0	0	0	No
0	Phagi *	WRD Stations	26°34'38"	75°33'34"	Phagi	Jaipur	IIIa	0	0	0	0	0	No
173	Phagi	Revenue Dpt.	26°34'40"	75°33'36"	Phagi	Jaipur	IIIa	1957	2010	6480	0	8	Yes
428	Sambhar	Revenue Dpt.	26°55'00"	75°09'60"	Sambhar	Jaipur	IIIa	1959	2010	6240	0	22	Yes
161	Sri Nagar	Revenue Dpt.	26°26'05"	74°46'31"	Shrinagar	Ajmer	IIIa	1957	2010	6480	1	52	Yes
156	Gegal	Revenue Dpt.	26°31'60"	74°45'00"	Shrinagar	Ajmer	IIIa	1957	2010	6480	2	153	Yes
0	Sikrai *	WRD Stations	26°55'00"	76°42'00"	Sikrai	Dausa	IIIa	0	0	0	0	0	No
226	Sikrai	Revenue Dpt.	26°55'00"	76°42'00"	Sikrai	Dausa	IIIa	1957	2010	6480	1	46	Yes
0	Toda Rai Singh *	WRD Stations	26°01'60"	75°28'60"	Todaraisingh	Tonk	IIIa	0	0	0	0	0	No
131	Toda Rai Singh	Revenue Dpt.	26°01'60"	75°28'60"	Todaraisingh	Tonk	IIIa	1957	2010	6480	0	7	Yes
133	Tonk *	WRD Stations	26°10'00"	75°47'60"	Tonk	Tonk	IIIa	1957	2010	6480	0	15	Yes
132	Tonk	Revenue Dpt.	26°10'00"	75°47'60"	Tonk	Tonk	IIIa	1961	2001	4920	12	578	Yes
797	Peeplu *	WRD Stations	26°17'46"	75°43'05"	Tonk	Tonk	IIIa	0	0	0	0	0	No

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
177	Pipalu	Revenue Dpt.	26°17'46"	75°43'05"	Tonk	Tonk	IIIa	1967	2010	5280	2	124	Yes
577	Galwar *	WRD Stations	25°52'10"	76°10'56"	Uniara	Tonk	IIIa	1967	2010	5280	3	169	Yes
58	Galvania Bund *	WRD Stations	25°52'10"	76°10'56"	Uniara	Tonk	IIIa	1967	2010	5280	3	169	Yes
843	Thikariya *	WRD Stations	25°49'12"	76°07'19"	Uniara	Tonk	IIIa	0	0	0	0	0	No
861	Uniyara	Revenue Dpt.	25°54'55"	76°01'35"	Uniara	Tonk	IIIa	0	0	0	0	0	No
263	Paota	Revenue Dpt.	27°34'60"	76°05'00"	Viratnagar	Jaipur	IIIa	1959	2010	6240	2	133	Yes
633	Viratnagar	Revenue Dpt.	27°26'02"	76°10'26"	Viratnagar	Jaipur	IIIa	0	0	0	0	0	No
331	Mount Abu (A)	IMD Stations	24°36'01"	72°43'04"	Abu Road	Sirohi	IVa	1957	2001	5400	6	335	Yes
332	Mount Abu	Revenue Dpt.	24°36'01"	72°43'04"	Abu Road	Sirohi	IVa	1957	2010	6480	0	0	Yes
325	Abu Road	Revenue Dpt.	24°28'60"	72°47'60"	Abu Road	Sirohi	IVa	1957	2010	6480	0	8	Yes
660	Chandrabhaga *	WRD Stations	25°10'00"	74°04'00"	Amet	Rajsamand	IVa	0	0	0	0	0	No
73	Amet	Revenue Dpt.	25°18'30"	73°54'54"	Amet	Rajsamand	IVa	1957	2010	6480	0	0	Yes
148	Patan *	WRD Stations	25°54'35"	74°22'08"	Asind	Bhilwara	IVa	1962	2010	5880	7	430	Yes
116	Sawar	Revenue Dpt.	25°45'00"	74°13'00"	Asind	Bhilwara	IVa	1957	2010	6480	1	61	Yes
141	Asind	Revenue Dpt.	25°43'60"	74°19'00"	Asind	Bhilwara	IVa	1957	2010	6480	0	8	Yes
0	Shambhugarh	Revenue Dpt.	25°48'52"	74°25'17"	Asind	Bhilwara	IVa	0	0	0	0	0	No
142	Badnore	Revenue Dpt.	25°50'19"	74°16'56"	Asind	Bhilwara	IVa	1966	2010	5400	7	398	Yes
643	Bagor	Revenue Dpt.	25°21'28"	74°22'59"	Asind	Bhilwara	IVa	0	0	0	0	0	No
143	Banera	Revenue Dpt.	25°31'00"	74°40'00"	Banera	Bhilwara	IVa	1957	2010	6480	0	16	Yes
105	Udaipur *	WRD Stations	24°35'40"	73°41'23"	Bargaon	Udaipur	IVa	0	0	0	0	0	No
840	Swaroop Sagar *	WRD Stations	24°35'20"	73°41'11"	Bargaon	Udaipur	IVa	0	0	0	0	0	No
632	Wagon Dam *	WRD Stations	24°26'60"	74°27'00"	Bari Sadri	Chittor	IVa	0	0	0	0	0	No
86	Badi Sadri	Revenue Dpt.	24°26'60"	74°28'60"	Bari Sadri	Chittor	IVa	1957	2010	6480	0	0	Yes
5	Begun	Revenue Dpt.	24°59'10"	75°07'57"	Begun	Chittor	IVa	1957	2010	6480	0	16	Yes
98	Sandesar *	WRD Stations	24°40'00"	74°20'00"	Bhadesar	Chittor	IVa	1968	2010	5160	2	92	Yes
85	Bhadesar	Revenue Dpt.	24°41'60"	74°28'60"	Bhadesar	Chittor	IVa	1957	2010	6480	0	8	Yes
4	Bhainsrorgarh	Revenue Dpt.	24°58'10"	75°31'56"	Bhainsrorgarh	Chittor	IVa	1957	2010	6480	5	320	Yes
565	Rawat Bhata *	WRD Stations	24°55'00"	75°34'60"	Bhainsrorgarh	Chittor	IVa	0	0	0	0	0	No
675	Gandhi Sagar *	WRD Stations	24°41'11"	75°34'08"	Bhainsrorgarh	Chittor	IVa	0	0	0	0	0	No
152	Bhim	Revenue Dpt.	25°44'17"	74°04'45"	Bhim	Rajsamand	IVa	1957	2010	6480	0	0	Yes
109	Vallabhnagar *	WRD Stations	24°41'60"	74°00'00"	Bhindar	Udaipur	IVa	1968	2010	5160	17	861	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
84	Badgaon *	WRD Stations	24°42'26"	74°05'22"	Bhindar	Udaipur	IVa	1965	2010	5520	2	84	Yes
108	Vallabhnagar	Revenue Dpt.	24°41'60"	74°00'00"	Bhindar	Udaipur	IVa	1957	2010	6480	1	40	Yes
656	Bhopal Sagar *	WRD Stations	24°51'10"	74°12'17"	Bhopalsagar	Chittor	IVa	0	0	0	0	0	No
87	Bhopalsagar	Revenue Dpt.	24°51'10"	74°12'17"	Bhopalsagar	Chittor	IVa	1961	2010	6000	4	249	Yes
280	Chhoti Sadri	Revenue Dpt.	24°23'60"	74°42'00"	Chhoti Sadri	Pratapgarh	IVa	1957	2010	6480	0	8	Yes
146	Khari Dam *	WRD Stations	25°01'60"	74°49'60"	Chittaurgarh	Chittor	IVa	1958	2010	6360	3	219	Yes
97	Bassi Dam *	WRD Stations	25°01'60"	74°49'00"	Chittaurgarh	Chittor	IVa	0	0	0	0	0	No
96	Orai *	WRD Stations	25°01'60"	74°50'00"	Chittaurgarh	Chittor	IVa	1962	2010	5880	2	122	Yes
89	Chittaurgarh	Revenue Dpt.	24°54'03"	74°37'24"	Chittaurgarh	Chittor	IVa	1957	2010	6480	0	0	Yes
153	Deo Garh	Revenue Dpt.	25°31'44"	73°54'26"	Deogarh	Rajsamand	IVa	1959	2010	6240	2	124	Yes
90	Dungla	Revenue Dpt.	24°30'24"	74°19'50"	Dungla	Chittor	IVa	1957	2010	6480	0	0	Yes
92	Gangrar	Revenue Dpt.	25°03'00"	74°35'60"	Gangrar	Chittor	IVa	1957	2010	6480	0	0	Yes
778	Nai *	WRD Stations	24°33'04"	73°38'11"	Girwa	Udaipur	IVa	0	0	0	0	0	No
846	Udaysagar *	WRD Stations	24°34'60"	73°49'00"	Girwa	Udaipur	IVa	0	0	0	0	0	No
581	Udaipur Girwa	Revenue Dpt.	24°34'16"	73°43'30"	Girwa	Udaipur	IVa	0	0	0	0	0	No
680	Gogunda *	WRD Stations	24°45'00"	73°34'00"	Gogunda	Udaipur	IVa	0	0	0	0	0	No
76	Gogunda	Revenue Dpt.	24°45'00"	73°34'00"	Gogunda	Udaipur	IVa	1958	2010	6360	0	0	Yes
138	Vijaynagar	Revenue Dpt.	25°55'00"	74°39'60"	Hurda	Bhilwara	IVa	1959	2010	6240	1	69	Yes
685	Gulabpura *	WRD Stations	25°54'20"	74°39'34"	Hurda	Bhilwara	IVa	0	0	0	0	0	No
139	Agucha *	WRD Stations	25°49'60"	74°42'00"	Hurda	Bhilwara	IVa	1966	2010	5400	5	292	Yes
149	Sareri *	WRD Stations	25°41'51"	74°34'51"	Hurda	Bhilwara	IVa	1958	2010	6360	3	159	Yes
145	Hurda	Revenue Dpt.	25°55'00"	74°40'60"	Hurda	Bhilwara	IVa	1957	2010	6480	0	8	Yes
815	Rupaheli	Revenue Dpt.	25°47'17"	74°38'37"	Hurda	Bhilwara	IVa	0	0	0	0	0	No
0	Deoli *	WRD Stations	25°45'00"	75°25'00"	Jahazpur	Bhilwara	IVa	0	0	0	0	0	No
117	Jahazpur	Revenue Dpt.	25°36'00"	75°16'60"	Jahazpur	Bhilwara	IVa	1957	2010	6480	0	0	Yes
125	Deoli	Revenue Dpt.	25°45'00"	75°25'00"	Jahazpur	Bhilwara	IVa	1959	2010	6240	0	14	Yes
829	Shakargarh	Revenue Dpt.	25°27'34"	75°16'53"	Jahazpur	Bhilwara	IVa	0	0	0	0	0	No
137	Tatgarh	Revenue Dpt.	25°41'27"	73°58'11"	Jawaja	Ajmer	IVa	1957	2010	6480	1	61	Yes
785	Ongana *	WRD Stations	24°31'19"	73°21'42"	Jhadol	Udaipur	IVa	0	0	0	0	0	No
320	Jhadol *	WRD Stations	24°23'60"	73°29'00"	Jhadol	Udaipur	IVa	0	0	0	0	0	No
321	Jhadol	Revenue Dpt.	24°23'60"	73°29'00"	Jhadol	Udaipur	IVa	1967	2010	5280	0	7	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
672	Dewas *	WRD Stations	24°30'48"	73°30'13"	Jhadol	Udaipur	IVa	0	0	0	0	0	No
834	Som Pick Up Weir *	WRD Stations	23°56'29"	73°45'38"	Jhadol	Udaipur	IVa	0	0	0	0	0	No
708	Kapasan *	WRD Stations	24°52'60"	74°19'00"	Kapasan	Chittor	IVa	0	0	0	0	0	No
94	Kapasan	Revenue Dpt.	24°52'60"	74°19'00"	Kapasan	Chittor	IVa	1957	2010	6480	0	8	Yes
779	Nand Samand *	WRD Stations	24°55'36"	73°46'58"	Khamnor	Rajsamand	IVa	0	0	0	0	0	No
78	Nathdwara	Revenue Dpt.	24°55'00"	73°50'00"	Khamnor	Rajsamand	IVa	1958	2010	6360	1	40	Yes
665	Chikliyawas *	WRD Stations	25°01'43"	73°43'45"	Khamnor	Rajsamand	IVa	0	0	0	0	0	No
307	Som Ka Gadar *	WRD Stations	24°01'47"	73°37'50"	Kherwara	Udaipur	IVa	1962	2010	5880	6	343	Yes
718	Kherwada *	WRD Stations	23°58'60"	73°35'60"	Kherwara	Udaipur	IVa	0	0	0	0	0	No
298	Babalwara *	WRD Stations	24°05'44"	73°27'42"	Kherwara	Udaipur	IVa	1962	2010	5880	15	861	Yes
77	Kherwada	Revenue Dpt.	23°58'60"	73°35'60"	Kherwara	Udaipur	IVa	1957	2010	6480	0	8	Yes
862	Kotra *	WRD Stations	24°22'60"	73°10'60"	Kotra	Udaipur	IVa	0	0	0	0	0	No
315	Kotra	Revenue Dpt.	24°22'60"	73°10'60"	Kotra	Udaipur	IVa	1958	2010	6360	1	37	Yes
790	Paroli	Revenue Dpt.	24°37'57"	73°23'59"	Kotra	Udaipur	IVa	0	0	0	0	0	No
847	Sei Dam *	WRD Stations	24°42'55"	73°11'48"	Kotra	Udaipur	IVa	0	0	0	0	0	No
733	Kothari *	WRD Stations	25°18'57"	74°59'48"	Kotri	Bhilwara	IVa	0	0	0	0	0	No
69	Kotri	Revenue Dpt.	25°25'60"	74°52'60"	Kotri	Bhilwara	IVa	1957	2010	6480	0	1	Yes
384	Kumbhalgarh	Revenue Dpt.	25°10'00"	73°34'00"	Kumbhalgarh	Rajsamand	IVa	1957	2010	6480	0	0	Yes
114	Meja Dam *	WRD Stations	25°23'36"	74°32'25"	Mandal	Bhilwara	IVa	1958	2010	6360	3	180	Yes
134	Jawaja	Revenue Dpt.	25°37'00"	74°13'00"	Mandal	Bhilwara	IVa	1957	2010	6480	1	45	Yes
113	Mandal	Revenue Dpt.	25°25'60"	74°32'60"	Mandal	Bhilwara	IVa	1957	2010	6480	0	0	Yes
568	Mandal	Revenue Dpt.	25°26'36"	74°33'60"	Mandal	Bhilwara	IVa	0	0	0	0	0	No
677	Gayangarh	Revenue Dpt.	25°39'13"	74°09'16"	Mandal	Bhilwara	IVa	0	0	0	0	0	No
710	Kareda	Revenue Dpt.	25°30'55"	74°13'34"	Mandal	Bhilwara	IVa	0	0	0	0	0	No
697	Jaitpura *	WRD Stations	25°15'01"	75°12'24"	Mandalgarh	Bhilwara	IVa	0	0	0	0	0	No
68	Mandalgarh	Revenue Dpt.	25°12'34"	75°05'04"	Mandalgarh	Bhilwara	IVa	1957	2010	6480	0	9	Yes
701	Kachola	Revenue Dpt.	25°23'56"	75°07'39"	Mandalgarh	Bhilwara	IVa	0	0	0	0	0	No
53	Bijolia	Revenue Dpt.	25°11'10"	75°21'56"	Mandalgarh	Bhilwara	IVa	1968	2010	5160	3	159	Yes
104	Udaipur Dabok (A)	IMD Stations	24°37'28"	73°51'35"	Mavli	Udaipur	IVa	1965	2001	4440	12	520	Yes
99	Bagolia *	WRD Stations	24°48'00"	73°50'00"	Mavli	Udaipur	IVa	1958	2010	6360	6	357	Yes
102	Maoli	Revenue Dpt.	24°49'00"	73°58'60"	Mavli	Udaipur	IVa	1957	2010	6480	0	0	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
93	Gambhiri *	WRD Stations	24°41'60"	74°43'00"	Nimbahera	Chittor	IVa	1962	2010	5880	2	137	Yes
95	Nimbahera	Revenue Dpt.	24°37'00"	74°42'00"	Nimbahera	Chittor	IVa	1957	2010	6480	0	0	Yes
334	Sarupsagar *	WRD Stations	24°52'00"	73°02'60"	Pindwara	Sirohi	IVa	1959	2010	6240	9	573	Yes
336	West Banas *	WRD Stations	24°42'25"	72°56'07"	Pindwara	Sirohi	IVa	1958	2010	6360	9	586	Yes
328	Kadambari *	WRD Stations	24°46'60"	73°05'00"	Pindwara	Sirohi	IVa	1962	2010	5880	9	550	Yes
390	Bhula *	WRD Stations	24°34'34"	72°59'14"	Pindwara	Sirohi	IVa	1957	2010	6480	10	658	Yes
333	Pindwara	Revenue Dpt.	24°48'00"	73°04'00"	Pindwara	Sirohi	IVa	1957	2010	6480	0	0	Yes
6	Gadola *	WRD Stations	24°10'00"	74°47'60"	Pratapgarh	Pratapgarh	IVa	1972	2010	4680	7	327	Yes
692	Jhakham Dam *	WRD Stations	24°10'17"	74°35'51"	Pratapgarh	Pratapgarh	IVa	0	0	0	0	0	No
283	Pratap Garh	Revenue Dpt.	24°04'00"	74°46'60"	Pratapgarh	Pratapgarh	IVa	1957	2010	6480	0	0	Yes
651	Bharai *	WRD Stations	24°58'60"	74°04'00"	Railmagra	Rajsamand	IVa	1962	2010	5880	6	373	Yes
80	Railmagra	Revenue Dpt.	25°01'60"	74°07'60"	Railmagra	Rajsamand	IVa	1958	2010	6360	0	7	Yes
115	Raipur	Revenue Dpt.	25°23'60"	74°09'00"	Raipur	Bhilwara	IVa	0	0	0	0	0	No
750	Mokhunda	Revenue Dpt.	25°18'16"	74°04'55"	Raipur	Bhilwara	IVa	0	0	0	0	0	No
0	Rajsamand *	WRD Stations	25°03'27"	73°53'55"	Rajsamand	Rajsamand	IVa	0	0	0	0	0	No
81	Rajsamand	Revenue Dpt.	25°03'27"	73°53'55"	Rajsamand	Rajsamand	IVa	1957	2010	6480	0	1	Yes
71	Matrikundia *	WRD Stations	25°02'08"	74°19'02"	Rashmi	Chittor	IVa	0	0	0	0	0	No
72	Rashmi	Revenue Dpt.	25°03'00"	74°22'00"	Rashmi	Chittor	IVa	1957	2010	6480	0	0	Yes
304	Rikhabdeo *	WRD Stations	24°07'00"	73°43'00"	Rishabhdeo	Udaipur	IVa	1958	2001	5280	7	343	Yes
582	Rikhabdeo	Revenue Dpt.	24°04'33"	73°41'31"	Rishabhdeo	Udaipur	IVa	0	0	0	0	0	No
676	Gangapur *	WRD Stations	25°13'08"	74°15'40"	Sahara	Bhilwara	IVa	0	0	0	0	0	No
70	Sahada	Revenue Dpt.	25°10'60"	74°13'60"	Sahara	Bhilwara	IVa	1957	2010	6480	4	250	Yes
670	Daya *	WRD Stations	24°12'25"	73°49'07"	Sarada	Udaipur	IVa	0	0	0	0	0	No
299	Jaisamand *	WRD Stations	24°14'52"	73°57'18"	Sarada	Udaipur	IVa	1958	2010	6360	9	558	Yes
713	Kejar *	WRD Stations	24°10'31"	73°50'40"	Sarada	Udaipur	IVa	0	0	0	0	0	No
828	Semari *	WRD Stations	24°03'20"	73°51'27"	Sarada	Udaipur	IVa	0	0	0	0	0	No
306	Sarada	Revenue Dpt.	24°10'60"	73°54'60"	Sarada	Udaipur	IVa	1957	2010	6480	0	8	Yes
140	Arwar Dam *	WRD Stations	25°48'11"	74°48'52"	Shahpura	Bhilwara	IVa	1958	2010	6360	3	217	Yes
151	Ummed Sagar *	WRD Stations	25°34'08"	74°54'28"	Shahpura	Bhilwara	IVa	1961	2010	6000	2	127	Yes
147	Nahar Sagar *	WRD Stations	25°43'00"	74°57'00"	Shahpura	Bhilwara	IVa	1958	2010	6360	3	217	Yes
150	Shahpura	Revenue Dpt.	25°37'25"	74°55'32"	Shahpura	Bhilwara	IVa	1957	2010	6480	0	8	Yes

WRIS Code	Station Name	Maintaining Department	Latitude	Longitude	Block	District	ACZ	Year From	Year To	Total Records	Interpolation Percentage, %	Total Monsoon Months Filled records	Used In Analysis
795	Phuliya Kalan	Revenue Dpt.	25°49'05"	74°57'50"	Shahpura	Bhilwara	IVa	0	0	0	0	0	No
555	Shahpura	Revenue Dpt.	25°37'25"	74°55'32"	Shahpura	Bhilwara	IVa	0	0	0	0	0	No
111	Bhilwara	Revenue Dpt.	25°19'40"	74°35'16"	Suwana	Bhilwara	IVa	1957	2010	6480	0	16	Yes
686	Hamirgarh	Revenue Dpt.	25°11'16"	74°37'59"	Suwana	Bhilwara	IVa	0	0	0	0	0	No
712	Karoei Kalan	Revenue Dpt.	25°13'37"	74°25'20"	Suwana	Bhilwara	IVa	0	0	0	0	0	No
313	Sallapat	Revenue Dpt.	23°10'48"	74°09'51"	Bagidora	Banswara	IVb	1957	2010	6480	0	7	Yes

* - Water Resources Department Stations; (A) - IMD Stations; No Suffix - Revenue Department Stations

Appendix 8

Agroclimatic Zone-wise Number of Excess, Normal, Deficient, Scanty and No-Rain Years

The following table shows the list of the number of years of excessive, normal, deficient, scanty, and no-rain years of each of the 327 stations used for the analysis during time span of 1957 to 2010. Each year's rainfall was compared with the mean rainfall of that station to arrive at the results. From the table it can be seen that there are few stations receiving no rain at all in some years. The definitions of excess, normal, deficient, scanty and no rain years are explained below the table.

Table 1 ACZ-wise Rainfall Analysis of Stations of Excess, Normal, Deficient, Scanty and No-Rain Years

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
ACZ Ia							
350	Pachpadra	245.2	17	14	16	7	0
354	Balotra	233.2	12	13	14	7	0
438	Barmer (a)	250.3	13	14	12	7	0
439	Barmer	263	14	15	17	8	0
443	Sheo	219.2	20	11	19	4	0
518	Jodhpur	341.2	14	14	12	5	0
520	Jodhpur *	356.2	16	12	24	2	0
523	Phalodi (a)	224.1	11	16	14	4	0
524	Phalodi	220	12	23	15	4	0
536	Osian	285.1	17	15	20	2	0
ACZ Ib							
458	Anupgarh	211.1	19	16	16	3	0
460	Bhadra	320.6	22	10	17	1	4
466	Dabla	223.3	15	12	10	15	0
467	Dhaban *	255	17	15	13	4	4
470	Ganganagar (a)	275.9	10	18	13	4	0
471	Ganganagar	260.7	12	27	9	6	0
475	Hanumangarh	218.1	21	14	12	3	4
481	Srikaranpur	226.2	13	20	16	5	0
484	Longwala *	182.2	16	11	13	12	0
490	Padampur	262.3	17	12	21	4	0
492	Pilibanga	186.7	16	22	12	3	1
495	Raisinghnagar	204.4	19	12	18	5	0
496	Sadulshahar	298.9	15	22	15	2	0
497	Sangriya	297.3	19	15	9	11	0
502	Suratgarh	206.9	14	22	10	7	1
504	Sunderpura *	195.9	16	13	7	4	5
507	T.A. Singh *	296.5	21	11	12	6	4
508	Tibbi	252.7	18	14	14	1	5
ACZ Ic							
444	Bikaner (a)	252.8	14	15	14	2	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
445	Bikaner	246.4	19	17	14	4	0
446	Lunkaransar	286.9	14	19	15	6	0
447	Kolayat	265.5	18	11	19	6	0
449	Nokha	310.5	13	19	20	2	0
456	Sujangarh	410.6	13	24	14	3	0
510	Jaisalmer (a)	183.6	17	9	9	9	1
511	Jaisalmer	191.9	16	14	15	9	0
526	Surpura *	260.8	17	8	19	9	0
ACZ IIa							
339	Degana	417.9	13	21	19	1	0
420	Khetri	569.4	14	22	18	0	0
421	Neem Ka Thana	510.4	15	20	18	1	0
422	Udaipur Wati	515.4	12	19	21	1	0
430	Nawa	445.6	13	20	20	1	0
431	Parbatsar	417.2	13	17	21	3	0
432	Dantaramgarh	462.8	16	21	15	2	0
433	Ramgarh Shethan	352.7	17	10	24	3	0
435	Chirawa	442.5	18	19	15	2	0
436	Jhunjhunu	402.1	19	17	17	1	0
437	Pilani (a)	402.3	11	20	10	3	0
450	Churu (a)	379.2	11	21	13	0	0
451	Churu	376	13	22	19	0	0
529	Ladnu	382.2	17	20	14	3	0
532	Fatehpur	401.8	15	19	18	2	0
533	Laxmangarh	429	18	16	16	4	0
534	Sikar *	461.8	16	10	16	3	0
535	Sikar	489.1	17	15	17	5	0
ACZ IIb							
341	Girinanda *	377.7	14	20	15	5	0
348	Jaitaran	405.6	16	17	18	3	0
349	Meli Tank *	266.4	16	13	16	9	0
351	Siwana	351.6	15	13	20	6	0
353	Jaswant Sagar *	372.1	16	11	23	4	0
355	Bilara	415.8	14	17	20	3	0
359	Raipur	475	14	21	17	2	0
360	Raipur Luni *	392.3	12	15	13	5	0
361	Sardar Samand *	306.1	16	19	13	6	0
362	Sojat	397.2	16	18	17	3	0
363	Baniawas *	290.6	15	10	9	13	0
365	Jograwas *	247.7	14	10	12	13	0
371	Hemawas *	384.7	15	14	18	6	0
372	Pali	398.8	15	14	21	4	0
374	Desuri	621.4	16	14	22	2	0
375	Kharda *	316.4	15	13	17	8	0
379	Kana *	403.9	12	17	15	5	0
380	Muthana *	384.6	11	16	13	7	0
382	Sadri *	455.9	14	21	17	2	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
388	Sanderao *	366.5	8	20	10	6	0
389	Takhatgarh *	314	13	17	20	4	0
391	Ahore	391.8	18	15	14	7	0
409	Danta *	441.3	16	10	19	5	0
410	Ora *	387.1	15	13	17	9	0
411	Sirohi	599.7	18	10	22	4	0
413	Jaswantpura	477.6	19	8	19	8	0
543	Jalore	405.3	15	17	17	5	0
547	Sheoganj *	519.6	17	18	17	2	0
548	Reodhar *	620.2	14	17	17	6	0
561	Bali	555.3	13	19	19	3	0
ACZ IIIa							
58	Galvania Bund *	505.6	14	8	17	4	1
127	Moti Sagar *	477.5	14	18	13	3	0
128	Nasirda *	424	11	18	17	2	0
130	Panwar Sagar *	443.9	16	13	16	3	0
131	Toda Rai Singh	599.8	12	26	15	1	0
132	Tonk	386.5	20	1	0	2	13
133	Tonk *	618.9	12	27	14	1	0
135	Kekri	511.2	14	26	14	0	0
136	Masuda	480.1	13	14	18	3	0
154	Arain	419.8	17	13	19	4	0
155	Bhinai	432.9	17	17	14	6	0
156	Gegal	329.4	18	15	17	4	0
157	Goela	341.6	17	16	15	6	0
159	Nasira Bad	464.3	18	15	16	5	0
160	Sarwar	512.2	11	27	15	0	0
161	Sri Nagar	408	16	17	15	6	0
163	Lamba Hari Singh *	408	15	9	14	5	0
164	Tordi Sagar*	471.2	11	11	13	1	1
165	Chhaparwara *	425.5	15	15	11	4	0
171	Naraina	460.9	16	18	14	4	0
173	Phagi	525.9	14	19	20	1	0
175	Malpura	548.5	16	19	18	1	0
176	Mashi *	487.3	12	15	14	3	0
177	Pipalu	543.2	13	15	15	1	0
179	Niwai	591	16	18	19	1	0
180	Amber	635.7	17	20	16	1	0
181	Bassi	610	15	13	18	6	0
182	Chaksu	584	16	19	16	3	0
184	Jaipur	586.9	16	21	15	2	0
185	Jaipur (a)	605.1	13	16	15	1	0
186	Kanota *	570.4	13	20	14	3	0
187	Lalsot	664.4	13	25	16	0	0
188	Rahuwas *	512.8	14	16	12	3	0
190	Sanganer	566.4	13	25	14	2	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
220	Baswa	668.1	16	17	20	1	0
221	Dausa	642.1	12	24	18	0	0
222	Jamwa Ramgarh	630.6	16	14	24	0	0
226	Sikrai	692.4	17	19	15	3	0
262	Kotputli	603.4	15	21	16	2	0
263	Paota	658.7	17	17	15	3	0
343	Beawar *	520.5	17	16	20	1	0
344	Mangliawas	310.9	18	8	22	6	0
345	Pisangan	386.6	16	15	19	4	0
346	Pushkar	445.6	16	19	12	7	0
423	Ajmer (a)	545.7	9	21	13	0	0
424	Ajmer	519.9	13	23	17	1	0
426	Chomu	528.5	15	13	20	2	0
427	Phulera	455.5	13	24	16	1	0
428	Sambhar	511.8	13	22	15	2	0
577	Galwar *	520.8	13	13	15	2	1
ACZ IIIb							
8	Dholpur	675.2	15	22	15	2	0
9	Urmila Sagar *	534.7	14	22	13	3	0
158	Kishangarh	494.7	14	18	19	2	0
192	Bamanwas	682.4	12	27	14	1	0
193	Bonli	626.6	17	13	20	2	0
194	Gangapur City	684.5	13	23	16	2	0
196	Moran Sagar *	530.1	17	18	14	4	0
197	Kalisil *	600.5	18	17	16	2	0
198	Sapotra	625.1	15	17	10	5	0
199	Angai *	557.4	15	18	17	3	0
200	Bari	736.4	15	21	17	1	0
202	Sepau	633.9	11	26	16	1	0
203	Sirmathura	597.6	17	16	20	1	0
204	Talabshahi *	574.5	13	17	17	5	0
206	Ajan *	542.4	17	17	17	1	0
208	Bharatpur	643.9	15	27	10	2	0
209	Deeg	602.8	16	20	16	2	0
210	Halena *	519.7	16	14	12	4	0
211	Hingota *	629.6	13	18	11	2	0
212	Kaman	646.6	12	29	12	1	0
213	Kumher	576.5	13	30	10	1	0
214	Nadbai	730.4	13	26	12	3	0
215	Nagar	623.8	11	28	13	2	0
217	Sewar *	539.8	15	20	16	1	0
219	Weir	610.6	14	25	12	3	0
228	Mahuwa	622.3	10	25	16	3	0
229	Toda Bhim	635.8	14	24	15	1	0
230	Baretha *	555.8	13	18	13	2	0
231	Bayana	656.2	14	23	14	3	0
233	Baseri	566.6	14	24	15	1	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
234	Rupwas	634.3	15	20	18	1	0
235	Hindaun	585.5	15	20	15	2	1
236	Juggar *	523.9	13	16	9	7	0
238	Karauli	734.8	17	16	19	2	0
241	Nadoti	597.2	17	16	20	1	0
243	Alwar	662	13	25	15	1	0
244	Govindgarh	641.6	14	23	15	2	0
245	Kathumbar	589.2	14	24	14	2	0
247	Malakhera	642	14	24	14	2	0
248	Ramgarh	619.6	13	28	11	2	0
249	Rajgarh	629.6	17	21	14	2	0
250	Siliserh *	519.9	17	11	17	1	0
251	Thanagazi	722.9	13	24	15	2	0
252	Bansur	669.4	14	22	17	1	0
253	Behror	602	16	20	15	3	0
254	Kishangarh Bas	643.2	14	21	17	2	0
255	Kotkasim	664.4	18	18	15	3	0
256	Mandawar	677.6	15	19	16	4	0
257	Neemrana	643	17	17	16	4	0
258	Sodawas *	584.8	14	13	16	2	0
259	Tapukra	613.2	12	24	17	1	0
260	Tijara	638.7	15	25	12	2	0
406	Morel Dam *	522.2	14	10	10	4	0
541	Pahari	503.7	15	19	19	1	0
673	Dholpur (a)	664.9	12	19	12	0	0
ACZ IVa							
4	Bhainsrorgarh	779.9	14	23	17	0	0
5	Begun	789.8	13	26	14	1	0
6	Gadola *	702.4	9	15	15	0	0
53	Bijolia	746.1	13	19	7	4	0
68	Mandalgarh	737.2	13	27	14	0	0
69	Kotri	709	15	20	18	1	0
70	Sahada	592.8	13	25	16	0	0
72	Rashmi	661.9	8	32	14	0	0
73	Amet	514.2	17	19	17	1	0
76	Gogunda	628.7	13	22	18	0	0
77	Kherwada	592.8	13	27	14	0	0
78	Nathdwara	522.5	13	24	15	1	0
80	Railmagra	566.2	11	28	13	1	0
81	Rajsamand	529.6	13	26	13	2	0
84	Badgaon *	550.4	11	22	12	1	0
85	Bhadesar	703.2	12	32	10	0	0
86	Badi Sadri	775.7	12	28	14	0	0
87	Bhopalsagar	563.4	15	19	16	0	0
89	Chittaurgarh	779.3	12	29	13	0	0
90	Dungla	745.3	11	30	13	0	0
92	Gangrar	702.6	14	24	16	0	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
93	Gambhiri *	742.3	12	22	15	0	0
94	Kapasan	640.2	15	24	15	0	0
95	Nimbahera	834.2	10	30	14	0	0
96	Orai *	667.4	12	23	14	0	0
98	Sandesar *	486.7	8	21	12	2	0
99	Bagolia *	480.7	13	24	14	2	0
102	Maoli	600.4	13	25	15	1	0
104	Udaipur Dabok (a)	561.5	9	16	10	2	0
108	Vallabhnagar	589.8	9	33	11	1	0
109	Vallabhnagar *	536.4	13	19	9	2	0
111	Bhilwara	653.1	18	16	20	0	0
113	Mandal	556.5	14	22	18	0	0
114	Meja Dam *	519.9	16	18	17	2	0
116	Sawar	459.6	15	24	10	5	0
117	Jahazpur	696.9	16	24	14	0	0
125	Deoli	584.9	14	24	14	0	0
134	Jawaja	414	17	15	16	6	0
137	Tatgarh	474.8	19	18	11	6	0
138	Vijaynagar	394.2	16	19	12	5	0
139	Agucha *	394.7	15	10	17	3	0
140	Arwar Dam *	497.2	14	21	16	2	0
141	Asind	444	13	28	12	1	0
142	Badnore	374.6	15	13	16	1	0
143	Banera	611.7	15	21	17	1	0
145	Hurda	529.1	15	22	15	2	0
146	Khari Dam *	422.1	15	20	17	1	0
147	Nahar Sagar *	522.6	15	21	17	0	0
148	Patan *	327	13	18	13	5	0
149	Sareri *	456.3	14	23	15	1	0
150	Shahpura	598.7	12	31	11	0	0
151	Ummed Sagar *	493.1	14	16	20	0	0
152	Bhim	490.6	18	18	16	2	0
153	Deo Garh	526.7	12	25	13	2	0
280	Chhoti Sadri	864.5	10	31	13	0	0
283	Pratap Garh	891.2	10	28	15	1	0
298	Babalwara *	643.8	7	17	20	5	0
299	Jaisamand *	604	11	14	9	1	3
304	Rikhabdeo *	497.2	12	17	15	0	0
306	Sarada	533.8	9	28	16	1	0
307	Som Ka Gadar *	543.9	13	15	19	2	0
315	Kotra	795.2	14	21	16	2	0
321	Jhadol	655.3	11	21	12	0	0
325	Abu Road	639.6	13	21	13	7	0
328	Kadambari *	464.8	11	18	11	9	0
334	Sarupsagar *	361.6	17	17	5	6	7
336	West Banas *	414.5	17	18	5	6	7
331	Mount Abu (a)	1484.6	12	17	11	5	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
332	Mount Abu	1573.4	15	18	16	5	0
333	Pindwara	692.5	12	20	19	3	0
384	Kumbhalgarh	655	17	17	19	1	0
390	Bhula *	551.6	14	14	19	7	0
651	Bharai *	452.9	13	18	15	3	0
ACZ IVb							
3	Arnod	993	12	14	17	0	0
264	Arthuna	791.9	13	23	17	1	0
265	Banswara (a)	821.1	12	13	9	3	0
266	Banswara	1041.8	12	24	18	0	0
267	Bhungra	871.9	13	25	15	1	0
268	Danpur	1021.4	17	17	18	2	0
269	Garhi	800.4	14	22	17	1	0
270	Ghatol	895.6	12	28	14	0	0
271	Jagpura	764.5	13	28	11	2	0
273	Loharia	721.4	15	22	16	1	0
275	Pipalkhunt	873.8	9	20	11	0	0
288	Dhariawad	797.2	10	25	15	0	0
290	Aspur	678.1	15	17	22	0	0
292	Dewal	512.8	18	21	14	1	0
294	Dungarpur	726.5	13	23	18	0	0
295	Ganeshpur	586.8	17	17	16	4	0
296	Nithawa	654.4	16	22	14	2	0
297	Sabla	647.2	15	21	17	1	0
305	Salumber	684	13	28	12	1	0
308	Galiakot	772.7	12	23	18	1	0
309	Sagwara	756.2	13	27	14	0	0
310	Bagidora	907.6	11	23	10	0	0
312	Kushalgarh	981.6	16	22	15	1	0
314	Shergarh	766.4	13	22	15	2	2
322	Dhambola	729.7	14	21	18	1	0
323	Kanba	621.4	16	19	18	1	0
820	Sajjangarh	807.8	15	16	20	3	0
313	Sallapat	881.4	14	18	22	0	0
ACZ V							
12	Digod	778.6	13	26	14	1	0
15	Kota A.p. (a)	667.6	14	12	8	1	3
17	Kota Barrage *	648.7	13	13	13	1	3
19	Ladpura	721.2	12	24	18	0	0
21	Mansarowar *	664	13	19	11	2	0
25	Gangdhar	835.8	14	24	16	0	0
26	Aklera	902.2	14	28	12	0	0
31	Asnawar	881.1	13	25	13	3	0
32	Bakani	954.4	15	22	17	0	0
33	Bhimsagar *	541.4	11	15	16	1	0
34	Dug	839.9	14	20	19	1	0
36	Jhalawar	913.8	11	29	14	0	0

Station WRIS code	Station Name	Annual Mean Rainfall, mm	Excess #	Normal ##	Deficient ###	Scanty ####	No Rain #####
37	Jhalrapatan	928.6	13	24	17	0	0
38	Khanpur	824.8	11	31	11	1	0
39	Pirawa	986	17	17	20	0	0
40	Pachpahar	834.5	16	22	14	2	0
45	Ramganjmandi	872.8	12	27	13	2	0
46	Sangod	772.4	13	25	15	1	0
48	Bundi	702.6	12	26	15	1	0
49	Gudha Dam *	571.7	11	19	13	0	0
50	Hindoli	626.7	16	24	14	0	0
51	Nainwa	573.6	18	15	20	1	0
52	Talera	636.3	15	24	14	1	0
59	Atru	865.3	13	29	11	1	0
60	Baran	828.6	13	22	18	1	0
61	Chhabra	899.3	13	29	9	1	0
62	Chhipabarod	887	13	28	11	2	0
63	Kishanganj	785.4	13	27	11	3	0
64	Mangrol	759	12	30	12	0	0
65	Pipalda	738	13	25	14	2	0
66	Ummed Sagar *	332.9	13	2	0	0	16
120	Khandar	700.4	14	24	15	1	0
122	Sawai Madhopur	783.1	16	26	11	1	0
162	Chandsen *	447.8	15	7	19	2	0
178	Dheel *	570.4	14	15	12	4	0

(a)=IMD stations; *= Water resources Dept. Stations; No suffix= Revenue Dept. Stations

Source: WRD Daily Rainfall Data, 1957-2010

#	Percentage departure of realised rainfall from long run average rainfall is >=20%.
##	Percentage departure of realised rainfall from long run average rainfall is -19% to +19 %.
###	Percentage departure of realised rainfall from long run average rainfall is - 0% to-59%.
####	Percentage departure of realised rainfall from long run average rainfall is -60% to -99 %.
#####	Percentage departure of realised rainfall from long run average rainfall is -100 %.

Appendix 9

Box Plots Descriptive Statistics

A Box Plot, or box and whisker diagram, provides a simple graphical summary of a set of data. It is a graphical method of displaying five descriptive statistics:

- the median (50%),
- the upper (Q3,75%) and lower(Q1,25%) quartiles,
- the minimum (Min.) and maximum (Max) data values.

In addition, a box plot can help visualize two other elements:

- abnormal data (outliers)
- average

First created by John Tukey in a 1977 publication, Box Plots have evolved into a familiar and useful standard in data interpretation. Box plots are powerful tools for picturing and comparing datasets as they give both a visual view and a numerical summary of a distribution. With larger sample sizes a boxplot is especially helpful tool, since it makes no distributional assumptions nor does it require any prior estimate of a mean or standard deviation. The plot may be drawn either vertically or horizontally.

The "box" itself represents the middle 50 percent of the data. The upper boundary (also known as the "hinge") of the box locates the 75th percentile of the data set while the lower boundary indicates the 25th percentile. Quite simply, the 25th percentile represents the value where 25 percent of the data is lower, and likewise, the 75th percentile represents the value that 75 percent of the data falls below. The area between these two boundaries is known as the "inter-quartile range"(IQR) and this gives a useful indication of the "spread" of the middle 50 percent of the data. This is a more robust range for interpretation because the middle 50 percent is not affected by outliers or extreme values, and gives a less biased visualization of the data spread.

- If the median line within the box is not equidistant from the hinges then the data is skewed.
- The line in the box indicates the "median" (or central most value) of the data. Not to be confused with the "mean", the median is the value that is the middle of the data set when the values are ranked in order, resulting in the same number of values above as below. This is a measure of "central tendency", or in layman's terms, where the center of the data is.
- The "whiskers" of the box-plot are the vertical lines of the plot extending from the box, and indicate the minimum and maximum values in the dataset. If there are "outliers" in the data, the whiskers extend to their maximum of 1.5 times the inter-quartile range. {(Upper whisker = Min(Max,Q3+1.5×IQR), (Lower Whisker = Max(Min.,Q1-1.5×IQR)}

- The points outside the ends of the whiskers are outliers or suspected outliers. In a box plot, outliers[1] are defined as being those values that are:
  greater than Q3 + 1.5 × IQR (upper fence) or
  less than $Q1 - 1.5 \times IQR$ (lower fence)

Skewness

Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point.

- A skew of zero indicates perfect symmetry.
- A positive skew indicates that more values lie below the mean and the distribution has a 'tail' which extends towards the higher values.
- A negative skew indicates that more values lie above the mean and the distribution has a 'tail' which extends towards the lower values.

Now that the pieces of the Box Plot have been identified, it is useful to understand that the box, the whiskers, even the median can reveal much information about a dataset by virtue of their position, length, or size.

Descriptive statistics to understand the boxplots are presented in Tables 1 to 10.

A typical Boxplots and its elements are shown in Figure 1.

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[1] "Outliers are observations that have extreme values relative to other observations observed under the same conditions. Observations may be outliers because of a single large or small value of one variable or because of an unusual combination of values of two or more variables." From 'Statistical Design and Analysis of Experiments', Mason, Gunst, and Hess.

Figure 1 Elements of Boxplots

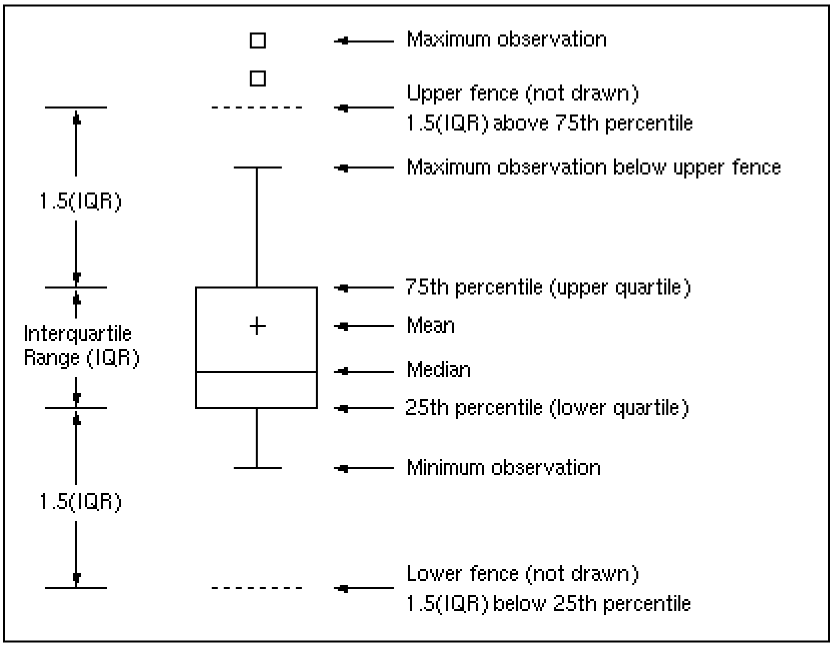
Maximum observation
Upper fence (not drawn)
1.5(IQR) above 75th percentile
Maximum observation below upper fence
1.5(IQR)
75th percentile (upper quartile)
Mean
Interquartile Range (IQR)
Median
25th percentile (lower quartile)
Minimum observation
1.5(IQR)
Lower fence (not drawn)
1.5(IQR) below 25th percentile

Table 1 Results of Descriptive Statistics of Annual Precipitation Analysis - ACZ Ia

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5× IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
350	37.0	147.3	220.8	333.7	589.6	186.4	245.2	613.2	-132.2	589.6	37.0	0.7
354	8.8	135.6	191.6	284.5	1106.0	149.0	233.2	508.0	-87.9	508.0	8.8	2.9
438	28.3	150.2	224.1	301.4	750.5	151.2	250.3	528.2	-76.7	528.2	28.3	1.1
439	37.1	164.5	221.0	321.3	759.0	156.8	263.0	556.5	-70.7	556.5	37.1	1.2
443	30.8	145.8	195.1	288.8	525.1	143.0	219.2	503.4	-68.7	503.4	30.8	0.7
518	114.0	209.0	327.0	452.5	672.2	243.5	341.2	817.8	-156.3	672.2	114.0	0.4
520	91.0	223.4	305.6	502.2	815.0	278.9	356.2	920.5	-194.9	815.0	91.0	0.7
523	68.0	139.7	210.9	257.0	516.9	117.3	224.1	433.0	-36.3	433.0	68.0	1.0
524	55.5	154.7	211.2	255.1	546.0	100.4	220.0	405.6	4.2	405.6	55.5	0.9
536	94.0	200.4	265.5	348.2	615.0	147.8	285.1	569.8	-21.3	569.8	94.0	0.7

Table 2 Results of Descriptive Statistics of Annual Precipitation Analysis - ACZ-Ib

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5× IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
458	52.0	132.1	205.1	271.5	426.0	139.4	211.1	480.6	-77.0	426.0	52.0	0.4
460	0.0	165.0	330.6	436.5	887.0	271.5	320.6	843.8	-242.3	843.8	0.0	0.4
466	20.0	83.6	183.4	304.0	857.0	220.4	223.3	634.6	-247.1	634.6	20.0	1.7
467	0.0	146.3	245.2	343.2	609.4	196.9	255.0	638.6	-149.1	609.4	0.0	0.4
470	63.0	189.0	262.3	326.0	752.0	137.0	275.9	531.5	-16.5	531.5	63.0	1.3
471	78.6	197.0	242.8	303.0	666.0	106.0	260.7	462.0	37.9	462.0	78.6	1.2
475	0.0	133.5	217.9	295.5	547.0	162.0	218.1	538.5	-109.5	538.5	0.0	0.3
481	73.0	152.4	209.8	263.1	668.9	110.8	226.2	429.3	-13.8	429.3	73.0	1.5
484	2.5	79.8	173.6	244.1	514.6	164.3	182.2	490.5	-166.6	490.5	2.5	0.9
490	50.0	157.1	223.4	333.0	628.0	175.9	262.3	596.8	-106.7	596.8	50.0	0.8
492	0.0	129.5	179.3	236.0	454.0	106.5	186.7	395.7	-30.2	395.7	0.0	0.7
495	36.8	128.0	204.2	276.8	419.0	148.8	204.4	499.9	-95.1	419.0	36.8	0.2
496	80.1	235.3	285.0	359.0	684.0	123.8	298.9	544.6	49.6	544.6	80.1	0.7
497	32.4	191.3	294.2	390.9	687.8	199.7	297.3	690.4	-108.3	687.8	32.4	0.3

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5× IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
502	0.0	140.5	199.0	253.6	512.8	113.1	206.9	423.2	-29.1	423.2	0.0	0.6
504	0.0	121.0	194.0	272.0	485.9	151.0	195.9	498.6	-105.5	485.9	0.0	0.2
507	0.0	149.1	290.6	433.8	766.0	284.7	296.5	860.7	-277.9	766.0	0.0	0.3
508	0.0	167.5	263.3	359.6	569.0	192.2	252.7	647.9	-120.8	569.0	0.0	-0.1

Table 3 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ Ic

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5× IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
444	54.4	174.1	243.0	323.2	558.5	149.1	252.8	546.9	-49.6	546.9	54.4	0.5
445	32.0	176.6	240.3	326.3	482.2	149.8	246.4	551.0	-48.1	482.2	32.0	0.0
446	64.0	165.2	262.7	355.1	783.0	189.9	286.9	639.9	-119.7	639.9	64.0	1.0
447	60.0	158.7	243.3	335.8	894.0	177.1	265.5	601.4	-107.0	601.4	60.0	1.5
449	71.0	211.3	285.8	368.8	769.4	157.5	310.5	605.0	-25.0	605.0	71.0	0.9
456	72.2	296.3	378.0	481.3	1057.7	185.1	410.6	758.9	18.7	758.9	72.2	1.2
510	0.0	82.1	181.0	276.1	478.0	194.0	183.6	567.1	-208.9	478.0	0.0	0.4
511	26.4	108.6	177.3	234.6	532.2	126.0	191.9	423.6	-80.5	423.6	26.4	1.0
526	15.2	152.0	196.4	373.0	894.0	221.0	260.8	704.5	-179.5	704.5	15.2	1.2

Table 4 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ IIa

Station WRIS code	Min, mm	Q1,mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
444	54.4	174.1	243.0	323.2	558.5	149.1	252.8	546.9	-49.6	546.9	54.4	0.5
445	32.0	176.6	240.3	326.3	482.2	149.8	246.4	551.0	-48.1	482.2	32.0	0.0
446	64.0	165.2	262.7	355.1	783.0	189.9	286.9	639.9	-119.7	639.9	64.0	1.0
447	60.0	158.7	243.3	335.8	894.0	177.1	265.5	601.4	-107.0	601.4	60.0	1.5
449	71.0	211.3	285.8	368.8	769.4	157.5	310.5	605.0	-25.0	605.0	71.0	0.9
456	72.2	296.3	378.0	481.3	1057.7	185.1	410.6	758.9	18.7	758.9	72.2	1.2
510	0.0	82.1	181.0	276.1	478.0	194.0	183.6	567.1	-208.9	478.0	0.0	0.4
511	26.4	108.6	177.3	234.6	532.2	126.0	191.9	423.6	-80.5	423.6	26.4	1.0
526	15.2	152.0	196.4	373.0	894.0	221.0	260.8	704.5	-179.5	704.5	15.2	1.2

Table 5 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ IIb

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
341	35.0	250.6	337.4	457.0	952.0	206.4	377.7	766.6	-59.1	766.6	35.0	0.9
348	122.7	279.7	381.1	537.7	872.5	258.0	405.6	924.7	-107.3	872.5	122.7	0.7
349	39.0	136.8	234.7	332.2	952.4	195.4	266.4	625.3	-156.4	625.3	39.0	1.8
351	34.3	225.1	286.1	438.3	1052.0	213.2	351.6	758.1	-94.8	758.1	34.3	1.4
353	92.0	241.5	306.0	485.5	1088.0	243.9	372.1	851.3	-124.4	851.3	92.0	1.5
355	128.0	280.6	348.3	506.5	1068.0	225.9	415.8	845.3	-58.2	845.3	128.0	1.4
359	116.0	338.4	443.7	565.1	972.4	226.8	475.0	905.2	-1.8	905.2	116.0	0.7
360	59.0	239.0	372.4	469.6	1156.0	230.6	392.3	815.4	-106.8	815.4	59.0	1.3
361	6.6	210.1	282.0	382.0	889.5	171.9	306.1	639.9	-47.8	639.9	6.6	1.0
362	77.0	259.7	368.9	499.7	878.9	240.0	397.2	859.7	-100.2	859.7	77.0	0.7
363	4.7	91.8	246.2	430.0	1050.4	338.2	290.6	937.3	-415.5	937.3	4.7	1.1
365	4.1	86.4	186.0	297.8	1008.8	211.4	247.7	614.8	-230.6	614.8	4.1	1.5
371	7.0	232.0	352.5	491.0	1085.0	259.0	384.7	879.5	-156.5	879.5	7.0	1.0
372	90.0	256.1	343.9	493.5	1022.4	237.4	398.8	849.6	-100.0	849.6	90.0	1.0
374	192.5	426.2	571.6	816.1	1710.1	389.9	621.4	1400.8	-158.6	1400.8	192.5	1.3
375	13.0	152.0	267.4	389.5	1058.0	237.6	316.4	745.8	-204.4	745.8	13.0	1.4
376	0.0	0.0	130.3	218.5	411.0	218.5	136.7	546.3	-327.8	411.0	0.0	0.5
379	85.0	261.6	357.6	482.3	1334.7	220.7	403.9	813.3	-69.4	813.3	85.0	1.8
380	79.5	249.3	337.3	453.1	1620.0	203.9	384.6	758.9	-56.5	758.9	79.5	2.5
382	62.0	316.4	428.5	543.8	1398.7	227.3	455.9	884.8	-24.6	884.8	62.0	1.5
388	68.5	240.5	349.9	411.9	1409.1	171.4	366.5	669.0	-16.6	669.0	68.5	2.3
389	50.1	181.3	284.4	365.2	769.6	183.8	314.0	640.9	-94.4	640.9	50.1	1.0

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
391	104.4	273.4	371.3	520.9	793.0	247.5	391.8	892.2	-97.9	793.0	104.4	0.5
409	110.9	241.0	359.5	579.2	1253.0	338.1	441.3	1086.4	-266.2	1086.4	110.9	1.2
410	30.5	216.1	325.5	464.3	1558.0	248.2	387.1	836.6	-156.2	836.6	30.5	1.9
411	190.9	366.6	503.2	798.0	1577.6	431.4	599.7	1445.1	-280.6	1445.1	190.9	1.1
413	100.0	266.3	387.7	600.8	1172.0	334.5	477.6	1102.5	-235.5	1102.5	100.0	0.8
543	51.3	274.1	342.1	540.5	1047.4	266.4	405.3	940.1	-125.5	940.1	51.3	0.9
547	106.6	313.4	464.8	668.9	1689.4	355.5	519.6	1202.2	-219.8	1202.2	106.6	1.7
548	54.0	402.7	539.0	751.8	1496.1	349.1	620.2	1275.4	-120.9	1275.4	54.0	1.1
561	174.0	349.5	505.2	652.9	1705.5	303.4	555.3	1108.1	-105.6	1108.1	174.0	1.7

Table 6 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ IIIa

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max., mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
58	0.8	295.7	415.3	691.3	1280.2	395.6	505.6	1284.6	-297.6	1280.2	0.8	0.6
127	103.0	321.0	465.1	610.5	1085.0	289.5	477.5	1044.8	-113.3	1044.8	103.0	0.5
128	33.0	299.5	384.8	494.4	935.0	194.9	424.0	786.7	7.2	786.7	33.0	0.9
130	141.0	290.7	392.3	586.3	1035.0	295.6	443.9	1029.7	-152.7	1029.7	141.0	0.9
131	210.0	461.2	605.5	686.8	1015.0	225.6	599.8	1025.2	122.8	1015.0	210.0	0.3
132	0.0	0.0	520.3	687.3	991.1	687.3	386.5	1718.3	-1031.0	991.1	0.0	0.0
133	221.3	483.5	607.4	710.2	1078.0	226.7	618.9	1050.2	143.5	1050.2	221.3	0.3
135	213.0	405.2	477.5	623.6	927.0	218.4	511.2	951.1	77.6	927.0	213.0	0.5
136	118.5	294.8	396.9	624.6	1200.0	329.8	480.1	1119.3	-200.0	1119.3	118.5	0.9
154	66.0	277.6	381.8	557.0	929.0	279.4	419.8	976.1	-141.5	929.0	66.0	0.7
155	102.1	296.5	448.8	561.9	928.0	265.4	432.9	959.9	-101.6	928.0	102.1	0.3
156	15.3	168.7	331.0	441.7	808.1	273.0	329.4	851.2	-240.9	808.1	15.3	0.5
157	58.9	243.8	332.8	442.3	710.0	198.4	341.6	739.9	-53.8	710.0	58.9	0.2
159	73.9	304.8	432.8	615.0	1082.0	310.3	464.3	1080.4	-160.6	1080.4	73.9	0.5
160	252.8	404.0	492.0	588.0	892.3	184.0	512.2	864.0	128.0	864.0	252.8	0.6
161	38.0	252.0	392.9	518.2	1731.0	266.2	408.0	917.4	-147.3	917.4	38.0	2.6
163	86.0	258.9	376.3	536.3	862.3	277.4	408.0	952.4	-157.1	862.3	86.0	0.5
164	169.5	270.2	449.2	639.4	974.1	369.2	471.2	1193.3	-283.6	974.1	169.5	0.6
165	123.0	279.0	405.1	543.0	990.0	264.0	425.5	939.0	-117.0	939.0	123.0	0.7
171	84.0	333.2	420.7	603.9	958.0	270.7	460.9	1009.9	-72.8	958.0	84.0	0.3
173	189.0	368.4	492.3	660.4	1058.1	292.0	525.9	1098.4	-69.6	1058.1	189.0	0.6
175	181.0	395.4	531.4	716.0	1058.0	320.6	548.5	1196.9	-85.6	1058.0	181.0	0.4
176	84.0	350.2	471.0	595.4	1031.6	245.2	487.3	963.1	-17.5	963.1	84.0	0.7
177	161.0	392.0	499.6	672.7	1165.0	280.8	543.2	1093.8	-29.2	1093.8	161.0	0.7
179	167.0	419.9	581.8	733.7	1107.4	313.8	591.0	1204.4	-50.9	1107.4	167.0	0.3
180	235.0	471.5	651.6	785.8	1086.0	314.3	635.7	1257.2	0.0	1086.0	235.0	0.0
181	119.6	368.4	553.9	765.9	1323.0	397.5	610.0	1362.2	-227.9	1323.0	119.6	0.6
182	136.1	408.9	548.3	716.8	1263.6	308.0	584.0	1178.8	-53.1	1178.8	136.1	0.7
184	85.0	409.0	562.8	711.9	1155.8	302.9	586.9	1166.2	-45.3	1155.8	85.0	0.4
185	198.1	449.4	571.4	762.2	1076.3	312.8	605.1	1231.4	-19.7	1076.3	198.1	0.4
186	144.4	391.2	573.1	696.4	1252.1	305.2	570.4	1154.2	-66.6	1154.2	144.4	0.5
187	275.0	521.4	653.7	789.2	1207.0	267.8	664.4	1190.8	119.7	1190.8	275.0	0.4
188	180.0	361.6	467.5	631.4	1173.6	269.8	512.8	1036.1	-43.1	1036.1	180.0	0.9
190	210.4	417.1	570.8	666.1	1080.9	249.0	566.4	1039.6	43.6	1039.6	210.4	0.3
220	252.0	478.0	588.8	845.8	1207.1	367.9	668.1	1397.6	-73.9	1207.1	252.0	0.7
221	300.0	489.1	602.9	744.3	1363.2	255.3	642.1	1127.2	106.1	1127.2	300.0	1.3
222	286.1	435.0	521.4	789.7	1173.3	354.7	630.6	1321.7	-97.0	1173.3	286.1	0.8
226	208.0	505.8	654.2	853.1	1652.0	347.3	692.4	1374.0	-15.2	1374.0	208.0	0.9
262	190.0	425.1	578.7	758.9	1234.6	333.8	603.4	1259.5	-75.6	1234.6	190.0	0.6
263	147.0	450.9	661.5	845.9	1180.0	395.0	658.7	1438.3	-141.5	1180.0	147.0	0.1
343	159.1	388.1	476.4	653.5	983.0	265.4	520.5	1051.6	-10.0	983.0	159.1	0.5
344	39.5	158.7	243.9	421.6	966.0	262.9	310.9	816.0	-235.6	816.0	39.5	1.2
345	78.2	229.3	366.6	475.0	925.0	245.8	386.6	843.6	-139.4	843.6	78.2	0.9
346	29.0	252.9	431.0	556.8	1167.0	303.9	445.6	1012.6	-203.0	1012.6	29.0	0.7
423	246.2	413.1	503.4	618.4	1101.7	205.3	545.7	926.4	105.2	926.4	246.2	1.0
424	205.3	395.5	472.8	615.1	1026.1	219.6	519.9	944.4	66.1	944.4	205.3	0.7
426	205.0	357.3	492.1	687.0	998.0	329.7	528.5	1181.6	-137.3	998.0	205.0	0.5
427	108.0	347.7	443.5	543.2	872.0	195.6	455.5	836.6	54.4	836.6	108.0	0.4
428	175.0	375.9	479.7	613.8	1146.9	238.0	511.8	970.8	18.9	970.8	175.0	0.8

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max., mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
577	0.8	357.3	470.5	711.3	1067.0	354.0	520.8	1242.2	-173.6	1067.0	0.8	0.3

Table 7 Results of Descriptive Statistics of Annual Precipitation Analysis - ACZ-IIIb

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
8	171.8	500.8	637.6	827.3	1319.6	326.6	675.2	1317.1	10.9	1317.1	171.8	0.5
9	140.1	377.5	545.9	648.0	1082.8	270.5	534.7	1053.8	-28.3	1053.8	140.1	0.4
158	177.0	371.0	476.0	619.6	1193.0	248.6	494.7	992.5	-1.9	992.5	177.0	1.0
192	233.0	518.2	678.0	779.3	1727.0	261.1	682.4	1171.0	126.6	1171.0	233.0	1.5
193	97.0	401.3	603.3	797.0	1493.8	395.8	626.6	1390.6	-192.4	1390.6	97.0	0.8
194	205.8	511.0	683.3	804.2	1227.0	293.2	684.5	1244.0	71.2	1227.0	205.8	0.3
196	138.0	380.0	489.0	658.3	1452.0	278.3	530.1	1075.7	-37.4	1075.7	138.0	1.2
197	7.1	380.0	541.2	769.0	1384.0	389.0	600.5	1352.5	-203.5	1352.5	7.1	0.7
198	4.7	482.5	640.0	782.9	1519.0	300.4	625.1	1233.6	31.9	1233.6	31.9	0.1
199	164.0	392.5	543.8	677.0	1062.9	284.5	557.4	1103.8	-34.3	1062.9	164.0	0.4
200	260.6	564.4	704.4	900.0	1192.5	335.6	736.4	1403.3	61.1	1192.5	260.6	0.4
202	142.2	476.9	607.3	730.5	1182.1	253.6	633.9	1110.9	96.4	1110.9	142.2	0.8
203	212.0	423.5	552.0	752.6	1072.0	329.1	597.6	1246.3	-70.1	1072.0	212.0	0.4
204	10.0	374.3	523.6	676.2	2078.6	302.0	574.5	1129.2	-78.7	1129.2	10.0	2.0
206	122.4	370.1	503.3	660.9	1152.0	290.9	542.4	1097.2	-66.2	1097.2	122.4	0.7
208	218.5	550.4	644.4	783.4	1041.0	233.0	643.9	1133.0	200.9	1041.0	218.5	-0.3
209	102.5	451.2	550.4	749.6	1167.0	298.4	602.8	1197.2	3.5	1167.0	102.5	0.5
210	126.0	342.8	501.7	661.3	1147.0	318.5	519.7	1139.0	-135.0	1139.0	126.0	0.6
211	227.4	477.2	608.9	780.6	1307.7	303.4	629.6	1235.7	22.2	1235.7	227.4	0.7
212	207.0	522.5	638.7	761.3	1219.2	238.8	646.6	1119.5	164.2	1119.5	207.0	0.5
213	204.6	477.7	579.8	667.1	1031.6	189.4	576.5	951.1	193.7	951.1	204.6	0.2
214	144.9	586.6	678.9	854.1	1358.6	267.6	730.4	1255.4	185.2	1255.4	185.2	0.3
215	216.0	473.4	572.5	727.8	1277.0	254.4	623.8	1109.5	91.7	1109.5	216.0	0.8
217	210.0	409.0	516.1	737.9	955.0	328.9	539.8	1231.3	-84.4	955.0	210.0	0.3
219	183.0	468.9	632.0	736.5	1089.6	267.6	610.6	1137.9	67.5	1089.6	183.0	0.0
228	5.6	458.2	596.3	713.0	1608.0	254.8	622.3	1095.2	76.0	1095.2	76.0	1.4
229	163.0	473.3	629.3	761.0	1077.9	287.7	635.8	1192.5	41.8	1077.9	163.0	0.1
230	192.3	395.8	535.0	667.7	1258.0	271.9	555.8	1075.6	-12.1	1075.6	192.3	0.7
231	204.6	512.0	628.8	775.5	1314.0	263.5	656.2	1170.8	116.8	1170.8	204.6	0.6
233	178.0	450.0	563.3	676.9	1216.1	226.9	566.6	1017.1	109.7	1017.1	178.0	0.9
234	230.8	460.6	613.3	773.9	1155.9	313.3	634.3	1243.9	-9.3	1155.9	230.8	0.4
235	0.0	418.0	531.0	719.0	1396.3	301.0	585.5	1170.5	-33.5	1170.5	0.0	0.8
236	47.0	351.5	538.2	668.5	1175.0	317.0	523.9	1144.0	-123.9	1144.0	47.0	0.3
238	239.6	506.1	743.8	895.0	1329.4	388.9	734.8	1478.3	-77.3	1329.4	239.6	0.3
241	204.0	420.8	534.5	756.4	1250.0	335.7	597.2	1259.9	-82.7	1250.0	204.0	0.6
243	223.8	491.9	661.5	788.0	1445.1	296.1	662.0	1232.1	47.7	1232.1	223.8	0.7
244	213.0	483.3	592.1	775.3	1445.0	292.0	641.6	1213.2	45.4	1213.2	213.0	0.9
245	158.0	455.8	603.0	700.8	1206.0	245.0	589.2	1068.3	88.3	1068.3	158.0	0.5
247	135.0	497.8	597.7	774.3	1328.0	276.5	642.0	1189.0	83.1	1189.0	135.0	0.7
248	105.0	510.0	619.5	731.3	1251.0	221.3	619.6	1063.1	178.1	1063.1	178.1	0.4
249	205.0	476.5	603.3	789.4	1152.0	312.9	629.6	1258.8	7.1	1152.0	205.0	0.2
250	111.0	334.0	516.7	664.8	1093.0	330.8	519.9	1161.0	-162.2	1093.0	111.0	0.5
251	179.0	557.3	706.5	829.0	1272.0	271.8	722.9	1236.6	149.6	1236.6	179.0	0.2
252	123.0	474.8	624.5	799.2	1489.6	324.3	669.4	1285.6	-11.7	1285.6	123.0	0.9
253	216.0	444.8	552.3	733.7	1238.0	288.9	602.0	1167.0	11.4	1167.0	216.0	0.8
254	241.0	495.3	639.0	770.5	1253.0	275.2	643.2	1183.3	82.4	1183.3	241.0	0.5
255	197.0	474.3	654.8	862.7	1320.0	388.4	664.4	1445.3	-108.4	1320.0	197.0	0.4
256	155.0	460.5	674.0	818.7	1726.0	358.3	677.6	1356.1	-76.9	1356.1	155.0	0.9
257	108.0	417.3	636.6	802.6	1424.5	385.3	643.0	1380.5	-160.6	1380.5	108.0	0.5
258	151.6	389.7	539.0	765.3	1251.3	375.6	584.8	1328.7	-173.7	1251.3	151.6	0.6
259	247.0	432.5	543.0	697.2	1434.0	264.7	613.2	1094.3	35.5	1094.3	247.0	1.4
260	195.0	494.1	627.3	795.7	1139.0	301.6	638.7	1248.1	41.7	1139.0	195.0	0.2
406	31.0	337.5	482.1	675.8	1252.4	338.3	522.2	1183.2	-169.9	1183.2	31.0	0.5
453	121.0	299.3	390.6	514.7	971.5	215.5	417.4	837.9	-23.9	837.9	121.0	0.9
514	2.0	61.5	128.3	181.0	386.0	119.5	136.9	360.3	-117.8	360.3	2.0	0.6
541	197.4	360.3	488.0	618.8	1174.0	258.5	503.7	1006.6	-27.4	1006.6	197.4	0.8
673	289.5	490.5	640.9	808.6	1362.3	318.1	664.9	1285.7	13.3	1285.7	289.5	0.7

Table 8 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ IVa

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3,mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
4	321.7	585.5	758.0	932.7	1463.0	347.2	779.9	1453.5	64.7	1453.5	321.7	0.7
5	231.0	625.4	726.0	864.8	1788.0	239.4	789.8	1223.9	266.3	1223.9	266.3	1.1
6	294.0	507.5	626.0	812.9	1637.3	305.4	702.4	1271.1	49.3	1271.1	294.0	1.4
53	136.3	577.0	790.0	961.0	1220.0	384.0	746.1	1537.0	1.0	1220.0	136.3	-0.5
68	402.0	588.0	719.5	868.5	1414.0	280.5	737.2	1289.3	167.3	1289.3	402.0	0.8
69	265.0	531.2	674.0	860.3	1569.0	329.1	709.0	1353.9	37.6	1353.9	265.0	0.9
70	272.0	459.8	568.0	699.9	1226.0	240.1	592.8	1060.1	99.6	1060.1	272.0	0.8
72	303.9	528.8	662.6	740.2	1465.7	211.4	661.9	1057.3	211.7	1057.3	303.9	1.3
73	206.0	366.0	542.5	657.2	882.0	291.2	514.2	1094.0	-70.8	882.0	206.0	0.0
76	264.7	473.6	579.0	738.3	1670.0	264.7	628.7	1135.4	76.6	1135.4	264.7	1.9
77	260.5	467.0	564.0	700.5	1332.0	233.5	592.8	1050.8	116.8	1050.8	260.5	0.9
78	137.0	397.3	487.0	622.0	1007.6	224.7	522.5	959.1	60.3	959.1	137.0	0.7
80	189.6	452.7	538.3	636.0	1418.0	183.3	566.2	911.0	177.8	911.0	189.6	1.4
81	190.0	423.8	517.2	625.6	1039.0	201.9	529.6	928.4	120.9	928.4	190.0	0.6
84	207.8	429.8	532.9	628.0	1258.0	198.3	550.4	925.4	132.4	925.4	207.8	1.2
85	356.0	589.5	666.4	790.6	1228.9	201.1	703.2	1092.3	287.8	1092.3	356.0	0.7
86	366.0	618.3	747.9	886.2	1441.4	267.9	775.7	1288.1	216.4	1288.1	366.0	0.7
87	262.0	437.0	518.7	685.0	1332.0	248.0	563.4	1057.0	64.9	1057.0	262.0	1.3
89	389.7	628.7	770.8	860.8	1330.2	232.1	779.3	1208.9	280.7	1208.9	389.7	0.6
90	349.0	611.1	714.4	878.9	1638.2	267.8	745.3	1280.6	209.4	1280.6	349.0	1.1
92	369.0	536.5	693.9	840.6	1120.0	304.1	702.6	1296.7	80.3	1120.0	369.0	0.4
93	309.0	538.0	756.6	885.6	1324.7	347.6	742.3	1407.0	16.6	1324.7	309.0	0.3
94	340.0	469.5	605.1	785.8	1222.3	316.3	640.2	1260.1	-4.9	1222.3	340.0	0.9
95	406.5	677.8	803.1	933.2	2263.2	255.4	834.2	1316.3	294.6	1316.3	406.5	2.7
96	325.0	505.1	664.0	797.0	1191.0	291.9	667.4	1234.9	67.3	1191.0	325.0	0.5
98	152.0	353.8	483.0	561.9	1400.0	208.1	486.7	874.0	41.6	874.0	152.0	2.1
99	107.0	357.6	456.7	568.0	1030.9	210.4	480.7	883.6	42.0	883.6	107.0	0.8
102	128.0	439.0	602.6	714.2	1188.7	275.2	600.4	1126.9	26.2	1126.9	128.0	0.4
104	219.0	394.0	546.0	646.7	1383.5	252.7	561.5	1025.8	14.9	1025.8	219.0	1.4
108	140.0	481.8	567.0	679.8	1415.8	198.0	589.8	976.7	184.9	976.7	184.9	1.5
109	2.9	428.8	504.8	648.9	1399.0	220.1	536.4	979.1	98.6	979.1	98.6	1.1
111	307.0	470.0	635.5	829.0	1120.0	359.0	653.1	1367.5	-68.4	1120.0	307.0	0.3
113	268.0	427.3	510.6	669.5	982.0	242.3	556.5	1032.9	63.9	982.0	268.0	0.6
114	137.0	369.0	514.2	642.0	965.0	273.0	519.9	1051.5	-40.5	965.0	137.0	0.3
115	164.3	415.9	525.0	654.1	1147.3	238.3	550.2	1011.5	58.5	1011.5	164.3	0.7
116	140.2	340.4	439.0	554.6	957.5	214.2	459.6	876.0	19.0	876.0	140.2	0.4
117	312.0	554.7	697.1	848.5	1112.7	293.9	696.9	1289.3	113.9	1112.7	312.0	0.2
125	271.1	463.0	552.2	709.3	1019.3	246.4	584.9	1078.8	93.4	1019.3	271.1	0.5
134	23.0	256.5	383.4	526.6	968.0	270.2	414.0	931.9	-148.8	931.9	23.0	0.6
137	85.0	317.5	443.8	598.1	914.0	280.6	474.8	1018.9	-103.4	914.0	85.0	0.1
138	69.0	287.8	363.2	524.5	674.5	236.8	394.2	879.6	-67.4	674.5	69.0	0.0
139	91.9	282.0	381.0	499.2	749.0	217.2	394.7	825.0	-43.8	749.0	91.9	0.3
140	170.1	360.9	470.0	601.0	1147.0	240.1	497.2	961.1	0.8	961.1	170.1	0.9
141	163.2	364.0	432.1	519.6	806.6	155.6	444.0	753.0	130.6	753.0	163.2	0.4
142	45.0	260.2	347.0	454.2	872.0	194.0	374.6	745.1	-30.7	745.1	45.0	0.7
143	243.0	451.0	564.2	780.2	1179.0	329.3	611.7	1274.1	-43.0	1179.0	243.0	0.7
145	204.0	389.6	521.4	661.1	1060.0	271.5	529.1	1068.3	-17.6	1060.0	204.0	0.6
146	152.0	315.0	390.7	507.3	898.7	192.3	422.1	795.8	26.6	795.8	152.0	0.9
147	246.8	378.0	494.0	644.0	1154.0	266.0	522.6	1043.0	-21.0	1043.0	246.8	1.3
148	58.0	228.0	307.0	392.0	874.0	164.0	327.0	638.0	-18.0	638.0	58.0	1.1
149	176.0	340.0	425.2	588.0	772.8	248.0	456.3	960.0	-32.0	772.8	176.0	0.5
150	283.0	508.5	585.2	679.8	1044.0	171.3	598.7	936.6	251.6	936.6	283.0	0.4
151	204.3	361.0	450.0	607.2	1075.0	246.2	493.1	976.6	-8.3	976.6	204.3	0.9
152	110.0	358.7	458.0	642.5	944.0	283.8	490.6	1068.2	-67.0	944.0	110.0	0.3
153	115.1	382.7	501.0	604.1	1294.0	221.4	526.7	936.1	50.7	936.1	115.1	1.0
280	378.0	701.3	863.0	989.4	1622.1	288.2	864.5	1421.7	269.0	1421.7	378.0	0.7
283	359.7	680.8	904.0	1014.5	1668.7	333.7	891.2	1515.0	180.2	1515.0	359.7	0.5
298	68.0	325.8	499.5	618.0	2969.8	292.2	643.8	1056.3	-112.5	1056.3	68.0	3.0
299	0.0	362.8	609.3	774.3	1715.5	411.5	604.0	1391.5	-254.5	1391.5	0.0	0.8
304	260.0	339.9	492.3	606.6	945.8	266.7	497.2	1006.7	-60.2	945.8	260.0	0.7
306	187.0	423.3	519.8	615.8	1155.0	192.5	533.8	904.5	134.5	904.5	187.0	1.3
307	62.0	369.0	483.0	662.0	1290.0	293.0	543.9	1101.5	-70.5	1101.5	62.0	0.9

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3,mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
315	164.5	566.9	714.7	954.0	2068.0	387.1	795.2	1534.7	-13.8	1534.7	164.5	1.1
321	273.8	515.8	599.9	778.8	1475.1	263.0	655.3	1173.3	121.3	1173.3	273.8	1.1
325	115.0	454.3	560.9	749.3	1650.4	295.0	639.6	1191.7	11.8	1191.7	115.0	1.0
331	334.2	1013.2	1265.0	1816.6	3245.9	803.4	1484.6	3021.7	-191.9	3021.7	334.2	0.7
332	367.6	1102.8	1402.0	1989.3	3621.2	886.6	1573.4	3319.2	-227.1	3319.2	367.6	0.8
328	55.0	263.1	423.9	529.6	2053.0	266.6	464.8	929.4	-136.8	929.4	55.0	2.4
334	0.4	135.4	365.2	531.5	900.0	396.1	361.6	1125.6	-458.7	900.0	0.4	0.2
336	0.4	228.4	423.8	617.0	1434.0	388.6	414.5	1199.9	-354.5	1199.9	0.4	0.6
333	145.7	516.3	613.7	800.9	2115.6	284.7	692.5	1227.9	89.2	1227.9	145.7	1.8
384	178.4	463.0	627.0	802.9	1537.0	339.9	655.0	1312.7	-46.8	1312.7	178.4	0.9
390	8.4	324.6	453.4	660.1	1553.7	335.5	551.6	1163.3	-178.6	1163.3	8.4	1.1
651	148.0	319.8	421.0	558.8	1060.0	239.0	452.9	917.3	-38.8	917.3	148.0	1.1

Table 9 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ IVb

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5×IQR, mm	Q1-1.5×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
3	503.0	701.5	885.0	1200.9	2518.0	499.4	993.0	1949.9	-47.5	1949.9	503.0	1.5
264	295.7	560.7	757.9	945.5	1705.0	384.8	791.9	1522.6	-16.4	1522.6	295.7	0.8
265	228.0	615.3	859.4	1031.6	1636.0	416.3	821.1	1656.2	-9.2	1636.0	228.0	0.3
266	509.8	719.9	968.0	1200.0	2591.0	480.1	1041.8	1920.1	-0.2	1920.1	509.8	1.5
267	184.0	675.6	797.0	1035.8	1958.0	360.3	871.9	1576.2	135.2	1576.2	184.0	1.0
268	393.8	717.1	964.6	1266.5	2271.0	549.4	1021.4	2090.5	-106.9	2090.5	393.8	0.9
269	247.3	624.6	756.6	993.4	1802.0	368.8	800.4	1546.6	71.4	1546.6	247.3	0.9
270	366.5	720.4	817.4	1022.4	1802.0	302.1	895.6	1475.5	267.3	1475.5	366.5	0.9
271	170.2	624.2	730.0	899.9	1581.6	275.6	764.5	1313.3	210.8	1313.3	210.8	0.6
273	274.6	514.6	675.6	899.3	1704.0	384.7	721.4	1476.2	-62.4	1476.2	274.6	0.9
274	179.2	602.6	795.5	938.4	2019.0	335.8	846.5	1442.2	98.8	1442.2	179.2	1.3
275	365.0	692.7	810.8	1015.4	1804.0	322.7	873.8	1499.5	208.7	1499.5	365.0	1.1
288	327.0	610.0	784.7	887.1	2078.6	277.1	797.2	1302.8	194.4	1302.8	327.0	1.9
290	279.9	481.0	640.4	815.8	1494.0	334.7	678.1	1317.8	-21.1	1317.8	279.9	1.2
292	202.0	408.8	471.5	652.7	863.0	243.9	512.8	1018.5	42.9	863.0	202.0	0.1
294	319.0	529.4	707.9	850.6	1611.0	321.2	726.5	1332.3	47.7	1332.3	319.0	1.0
295	115.7	406.6	568.5	725.5	1320.0	318.9	586.8	1203.9	-71.8	1203.9	115.7	0.5
296	245.4	485.7	623.0	798.0	1312.0	312.3	654.4	1266.5	17.2	1266.5	245.4	0.8
297	231.2	438.1	622.9	838.0	1434.0	399.9	647.2	1437.8	-161.8	1434.0	231.2	0.6
305	262.0	551.5	652.5	777.0	1556.5	225.5	684.0	1115.3	213.3	1115.3	262.0	1.2
308	301.0	561.0	743.5	898.3	1766.6	337.3	772.7	1404.1	55.1	1404.1	301.0	1.3
309	309.2	605.8	733.0	888.8	1588.0	283.0	756.2	1313.3	181.3	1313.3	309.2	0.8
310	495.0	744.3	803.6	1090.2	1833.0	346.0	907.6	1609.2	225.3	1609.2	495.0	1.0
312	390.0	718.3	922.5	1257.8	1786.0	539.5	981.6	2067.0	-91.0	1786.0	390.0	0.4
314	0.0	544.0	692.9	913.3	1771.2	369.3	766.4	1467.3	-10.0	1467.3	0.0	0.7
322	256.0	510.0	704.0	884.3	1633.0	374.3	729.7	1445.7	-51.5	1445.7	256.0	0.8
323	26.0	446.0	590.8	761.3	1531.5	315.3	621.4	1234.1	-26.9	1234.1	26.0	0.9
820	302.0	526.8	752.0	972.3	1904.0	445.5	807.8	1640.5	-141.5	1640.5	302.0	1.1

Table 10 Results of Descriptive Statistics of Annual Precipitation Analysis – ACZ V

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
12	234.0	611.4	782.0	904.1	1548.0	292.7	778.6	1343.1	172.4	1343.1	234.0	0.4
15	1.0	494.3	649.2	853.0	1590.1	358.7	667.6	1391.1	-43.8	1391.1	1.0	0.4
17	1.0	441.6	592.5	859.3	1548.6	417.7	648.7	1485.9	-185.1	1485.9	1.0	0.6
19	321.7	559.5	717.5	842.1	1475.5	282.6	721.2	1266.0	135.7	1266.0	321.7	0.7
21	197.0	487.0	659.0	852.0	1196.0	365.0	664.0	1399.5	-60.5	1196.0	197.0	0.3
25	429.9	629.7	809.3	996.8	1709.2	367.0	835.8	1547.3	79.2	1547.3	429.9	0.9
26	413.5	750.9	825.4	1065.5	1542.1	314.7	902.2	1537.5	278.9	1537.5	413.5	0.6
31	139.6	690.2	850.5	1015.3	1773.2	325.1	881.1	1502.9	202.6	1502.9	202.6	0.7
32	433.0	697.6	925.0	1162.2	1826.8	464.6	954.4	1859.0	0.8	1826.8	433.0	0.6
33	140.3	382.5	536.0	648.2	1261.0	265.7	541.4	1046.8	-16.1	1046.8	140.3	1.1
34	307.8	611.7	780.5	1001.7	2241.3	390.0	839.9	1586.7	26.7	1586.7	307.8	1.9
36	375.0	725.3	882.4	1029.4	1614.5	304.1	913.8	1485.6	269.2	1485.6	375.0	0.7

Station WRIS code	Min, mm	Q1, mm	Median, mm	Q3, mm	Max, mm	IQR, mm	Mean, mm	Q3+1.5 ×IQR, mm	Q1-1.5 ×IQR	Upper Whisker, mm	Lower Whisker, mm	Skewness
37	454.9	696.1	917.5	1105.1	1890.8	409.0	928.6	1718.6	82.6	1718.6	454.9	0.8
38	311.8	699.2	848.6	947.0	1386.4	247.8	824.8	1318.7	327.5	1318.7	327.5	0.0
39	492.2	735.5	904.1	1210.8	1778.0	475.2	986.0	1923.6	22.7	1778.0	492.2	0.5
40	203.5	621.5	832.7	1032.5	1358.8	411.0	834.5	1649.0	5.0	1358.8	203.5	0.0
45	224.8	688.9	880.2	1018.3	1608.4	329.4	872.8	1512.3	194.8	1512.3	224.8	0.1
46	63.5	571.2	761.5	918.6	1543.9	347.5	772.4	1439.8	50.0	1439.8	63.5	0.2
48	275.5	552.8	669.5	818.4	1245.4	265.7	702.6	1216.9	154.3	1216.9	275.5	0.5
49	235.7	439.8	545.5	690.6	1115.3	250.8	571.7	1066.7	63.7	1066.7	235.7	0.6
50	278.7	502.9	593.3	774.7	1176.0	271.8	626.7	1182.4	95.1	1176.0	278.7	0.4
51	186.0	386.8	529.0	733.7	1135.0	346.9	573.6	1254.0	-133.6	1135.0	186.0	0.5
52	152.2	506.6	596.1	784.8	1241.0	278.2	636.3	1202.1	89.4	1202.1	152.2	0.5
59	237.5	707.6	841.4	1023.0	1621.0	315.4	865.3	1496.1	234.5	1496.1	237.5	0.5
60	254.0	624.3	789.5	973.6	1537.4	349.3	828.6	1497.5	100.3	1497.5	254.0	0.6
61	170.8	756.3	924.5	1076.3	1452.1	320.0	899.3	1556.3	276.3	1452.1	276.3	-0.6
62	174.2	735.1	912.3	1055.5	1412.8	320.4	887.0	1536.1	254.5	1412.8	254.5	-0.5
63	156.1	630.6	759.9	914.6	1409.7	284.0	785.4	1340.5	204.7	1340.5	204.7	0.0
64	350.0	632.7	752.1	868.5	1626.5	235.9	759.0	1222.3	278.9	1222.3	350.0	1.1
65	239.0	557.0	738.0	872.4	1304.6	315.4	738.0	1345.4	83.9	1304.6	239.0	0.0
66	0.0	0.0	0.0	630.2	1091.0	630.2	332.9	1575.5	-945.3	1091.0	0.0	0.5
120	237.0	536.5	684.0	836.0	1253.9	299.5	700.4	1285.3	87.2	1253.9	237.0	0.3
122	295.0	658.5	786.0	967.4	1301.4	308.9	783.1	1430.8	195.1	1301.4	295.0	-0.1
162	132.0	258.7	370.0	634.0	959.6	375.3	447.8	1196.9	-304.2	959.6	132.0	0.7
178	88.0	364.2	556.0	738.0	1223.8	373.8	570.4	1298.7	-196.5	1223.8	88.0	0.5
525	42.0	149.3	233.5	321.5	676.5	172.3	241.6	579.9	-109.1	579.9	42.0	0.7

Appendix 10

Statistics of Consecutive Days of Maximum Rainfall in 327 Raingauge Stations in Various Agroclimatic Zones

This Appendix shows statistics of temporal variability of maximum rainfall events occurred over various raingauge stations in Rajasthan.

The definitions of various statistical parameters presented in this appendix are described below.

Mean:

In statistics, the mean is the mathematical average of a set of numbers. The average is calculated by adding up two or more scores and dividing the total by the number of scores.

Median:

The median is the middle number in a sorted list of numbers. To determine the median value in a sequence of numbers, the numbers must first be arranged in value order from lowest to highest. If there is an odd amount of numbers, the median value is the number that is in the middle, with the same amount of numbers below and above. If there is an even amount of numbers in the list, the middle pair must be determined, added together and divided by two to find the median value. The median can be used to determine an approximate average.

Mode:

Mode is the most frequently occurring value in a frequency distribution. If no number is repeated, then there is no mode for the list.

Standard Deviation:

Standard deviation (σ) is defined as the square root of the variance. It measures the variability about the mean of a data set: the closer to the mean, the lower the standard deviation. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values. Calculating the standard deviation involves squaring the difference between each data point and the mean, summing the squared differences, dividing by the number of data points, and finally taking the square root ($\sigma = \sqrt{E[(X - \mu)^2]}$.

Coefficient of Variation:

A statistical measure of the dispersion of data points in a data series around the mean. It is calculated as follows:

$$\text{Coefficient of Variation} = \frac{\textbf{Standard Deviation}}{\textbf{Expected Return}}$$

The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from each other. The advantage of the CV is that it is unit-less. This allows CVs to be compared to each other in ways that other measures, like standard deviations or root mean squared residuals, cannot be.

Skewness:

Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the centre point.

A skew of zero indicates perfect symmetry.

A positive skew indicates that more values lie below the mean and the distribution has a 'tail' which extends towards the higher values.

A negative skew indicates that more values lie above the mean and the distribution has a 'tail' which extends towards the lower values.

Kurtosis:

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. That is, data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak.

Table 1 Statistics of Consecutive Days of Maximum Rainfall in 327 Raingauge Stations in Various Agroclimatic Zones

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
ACZ Ia						
Balotra (354)	Coefficient of variation	0.9	1.0	1.0	1.0	0.8
	Kurtosis	10.2	10.5	15.6	11.9	2.0
	Maximum, mm	337.0	416.0	561.0	569.0	374.0
	Mean, mm	63.9	79.0	88.2	101.2	105.0
	Median, mm	45.4	60.0	66.8	73.4	78.9
	Minimum, mm	6.3	21.1	6.3	16.5	9.7
	Skewness	3.0	3.2	3.7	3.3	1.5
	Standard Deviation	59.3	76.5	90.0	105.5	88.3
Barmer (439)	Coefficient of variation	0.8	0.9	0.9	0.9	0.8
	Kurtosis	7.9	8.6	7.3	3.7	1.1
	Maximum, mm	312.0	472.0	475.0	426.0	448.0
	Mean, mm	66.3	86.4	92.2	100.9	141.0
	Median, mm	55.7	65.3	68.2	79.6	109.3
	Minimum, mm	16.4	0.8	17.6	16.9	25.8
	Skewness	2.5	2.7	2.6	1.9	1.4
	Standard Deviation	52.1	81.6	86.6	92.9	113.2
Barmer (a) (438)	Coefficient of variation	0.7	0.9	0.9	1.0	0.9
	Kurtosis	5.6	7.9	6.6	4.9	2.1
	Maximum, mm	253.6	436.4	438.4	454.7	455.7
	Mean, mm	65.4	83.0	90.1	99.5	120.5
	Median, mm	52.8	61.5	68.2	76.7	81.5
	Minimum, mm	10.4	2.6	10.4	10.0	20.9
	Skewness	2.2	2.6	2.4	2.2	1.7
	Standard Deviation	48.2	78.4	79.8	95.8	110.3
Jodhpur (518)	Coefficient of variation	0.5	0.6	0.5	0.5	0.5
	Kurtosis	0.5	2.0	0.7	-1.2	-0.6
	Maximum, mm	172.0	268.0	268.0	189.0	184.3
	Mean, mm	70.4	85.9	104.1	101.8	86.0
	Median, mm	65.0	81.3	97.8	96.9	71.4
	Minimum, mm	17.4	12.2	23.9	11.0	31.9
	Skewness	0.9	1.2	0.8	0.0	0.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
	Standard Deviation	35.4	52.8	52.5	49.5	43.1
Jodhpur * (520)	Coefficient of variation	0.5	0.6	0.5	0.7	0.8
	Kurtosis	0.5	1.2	1.7	4.4	5.2
	Maximum, mm	157.0	253.0	301.0	423.0	494.5
	Mean, mm	67.5	85.4	102.9	116.4	130.4
	Median, mm	61.5	74.6	88.4	94.6	95.7
	Minimum, mm	20.0	13.5	26.0	11.0	36.0
	Skewness	1.0	1.1	1.2	1.8	2.2
	Standard Deviation	32.9	48.7	55.4	77.0	98.5
Osian (536)	Coefficient of variation	0.4	0.5	0.5	0.5	0.4
	Kurtosis	-0.8	-0.5	-0.2	0.2	0.1
	Maximum, mm	125.0	177.0	204.0	210.0	214.0
	Mean, mm	62.9	74.7	85.8	82.9	100.7
	Median, mm	58.5	66.0	76.5	70.4	88.5
	Minimum, mm	16.0	13.0	28.2	20.0	42.2
	Skewness	0.5	0.6	0.6	0.9	0.8
	Standard Deviation	27.8	38.0	39.4	45.5	43.9
Pachpadra (350)	Coefficient of variation	0.6	0.7	0.6	0.7	0.6
	Kurtosis	0.9	2.1	2.7	3.3	2.9
	Maximum, mm	152.0	230.0	252.0	269.0	272.0
	Mean, mm	58.0	68.3	78.6	79.2	88.9
	Median, mm	53.5	61.0	71.0	74.1	79.0
	Minimum, mm	15.5	14.5	16.8	10.5	19.4
	Skewness	1.1	1.4	1.4	1.7	1.6
	Standard Deviation	33.5	44.7	46.5	55.4	57.4
Phalodi (524)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	3.8	0.5	1.0	-0.5	-1.4
	Maximum, mm	167.5	155.0	167.5	165.0	166.2
	Mean, mm	53.7	61.1	69.1	76.7	86.5
	Median, mm	48.9	57.5	62.1	70.5	80.5
	Minimum, mm	15.0	17.0	15.0	20.5	21.5
	Skewness	1.6	0.9	1.0	0.7	0.3
	Standard Deviation	28.0	30.8	32.8	43.0	49.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Phalodi (a) (523)	Coefficient of variation	0.6	0.6	0.6	0.4	0.4
	Kurtosis	7.1	-0.1	1.8	-1.0	-0.9
	Maximum, mm	225.0	155.0	225.0	180.0	166.2
	Mean, mm	57.9	62.1	74.6	100.5	99.3
	Median, mm	47.0	59.6	67.0	89.9	98.6
	Minimum, mm	10.5	1.5	17.0	43.2	38.8
	Skewness	2.3	0.8	1.3	0.6	0.1
	Standard Deviation	37.2	36.7	42.5	42.6	37.8
Sheo (443)	Coefficient of variation	0.6	0.8	0.7	0.8	0.8
	Kurtosis	3.0	3.4	4.3	-0.3	-1.8
	Maximum, mm	170.0	255.0	299.0	311.0	323.0
	Mean, mm	55.5	66.8	80.5	107.4	151.2
	Median, mm	50.5	57.6	69.6	77.8	97.1
	Minimum, mm	12.5	8.0	13.4	19.3	21.5
	Skewness	1.6	1.8	2.0	1.0	0.4
	Standard Deviation	31.9	50.5	55.9	89.2	113.9
ACZ Ib						
Anupgarh (458)	Coefficient of variation	0.5	0.6	0.5	0.3	0.3
	Kurtosis	0.3	2.7	1.1	-2.2	-2.2
	Maximum, mm	127.0	174.0	174.0	93.0	97.0
	Mean, mm	55.4	49.0	64.4	68.4	76.3
	Median, mm	49.5	45.0	58.5	64.0	79.0
	Minimum, mm	9.6	6.0	10.6	46.0	50.0
	Skewness	0.9	1.2	0.9	0.1	-0.1
	Standard Deviation	26.8	31.6	31.7	21.3	22.2
Bhadra (460)	Coefficient of variation	0.5	0.5	0.5	0.8	0.6
	Kurtosis	-0.4	1.5	5.0	2.1	0.2
	Maximum, mm	122.0	220.0	277.0	377.0	245.0
	Mean, mm	59.9	76.4	85.0	117.0	104.9
	Median, mm	59.6	68.0	76.0	92.0	71.0
	Minimum, mm	0.0	7.0	25.0	38.5	54.0
	Skewness	0.1	1.1	1.8	1.7	1.2
	Standard Deviation	30.8	41.6	44.9	89.5	61.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dabla (466)	Coefficient of variation	0.6	0.8	0.8	0.8	1.2
	Kurtosis	1.2	2.2	1.9	0.1	-0.9
	Maximum, mm	129.0	204.0	214.0	222.0	279.0
	Mean, mm	42.8	53.3	60.3	78.7	87.2
	Median, mm	38.9	43.2	46.5	61.7	30.6
	Minimum, mm	10.0	10.2	10.0	16.7	18.9
	Skewness	1.2	1.6	1.6	1.1	1.0
	Standard Deviation	26.8	45.1	48.0	64.7	103.3
Dhaban * (467)	Coefficient of variation	0.6	0.5	0.4	0.6	0.1
	Kurtosis	0.0	0.0	-0.5	-1.4	-2.8
	Maximum, mm	147.0	158.0	158.0	186.0	164.0
	Mean, mm	56.9	66.9	78.9	93.1	151.5
	Median, mm	53.5	57.0	76.0	80.0	151.5
	Minimum, mm	0.0	17.0	20.0	34.0	139.0
	Skewness	0.4	0.7	0.4	0.5	0.0
	Standard Deviation	32.7	35.1	34.4	52.5	17.7
Ganganagar (471)	Coefficient of variation	0.5	0.5	0.5	0.4	0.3
	Kurtosis	0.4	0.1	-0.6	-0.4	-1.5
	Maximum, mm	145.0	150.0	150.0	162.0	121.0
	Mean, mm	56.6	58.5	71.0	81.9	82.6
	Median, mm	52.5	56.0	71.4	88.0	83.3
	Minimum, mm	16.0	12.0	18.0	21.0	54.9
	Skewness	0.8	0.8	0.3	0.2	0.2
	Standard Deviation	27.9	30.7	33.1	35.6	23.2
Ganganagar (a) (470)	Coefficient of variation	0.6	0.7	0.6	0.8	0.6
	Kurtosis	-0.2	1.8	1.3	1.8	0.1
	Maximum, mm	149.2	204.8	225.3	232.5	191.0
	Mean, mm	60.3	61.3	76.4	67.8	74.8
	Median, mm	56.0	55.0	67.5	62.5	69.6
	Minimum, mm	14.5	3.0	18.0	4.1	6.3
	Skewness	0.7	1.2	1.1	1.3	0.7
	Standard Deviation	33.5	40.4	43.4	52.4	47.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Hanumangarh (475)	Coefficient of variation	0.6	0.5	0.5	0.7	0.0
	Kurtosis	1.9	-0.3	-0.1	-1.3	0.0
	Maximum, mm	160.0	118.0	160.0	145.0	63.0
	Mean, mm	51.1	53.3	70.1	67.6	63.0
	Median, mm	46.9	48.5	62.4	55.0	63.0
	Minimum, mm	0.0	14.0	20.0	30.0	63.0
	Skewness	1.1	0.7	0.7	0.8	0.0
	Standard Deviation	31.6	26.1	31.7	45.9	0.0
Longwala * (484)	Coefficient of variation	0.6	0.7	0.7	0.6	0.6
	Kurtosis	-0.9	-0.2	0.0	-0.8	-1.1
	Maximum, mm	68.3	107.9	125.1	149.1	184.2
	Mean, mm	31.0	40.5	45.8	68.4	87.9
	Median, mm	30.0	35.2	38.1	60.0	73.5
	Minimum, mm	2.5	2.6	2.5	17.9	33.4
	Skewness	0.3	0.8	0.9	0.7	0.6
	Standard Deviation	17.3	26.6	30.3	37.7	49.0
Padampur (490)	Coefficient of variation	0.6	0.7	0.6	0.5	0.3
	Kurtosis	5.5	3.1	2.7	-0.4	-1.7
	Maximum, mm	232.0	262.0	277.0	287.0	110.0
	Mean, mm	61.3	67.4	77.7	136.6	92.0
	Median, mm	54.0	54.0	59.9	120.0	101.5
	Minimum, mm	9.0	11.0	9.0	50.0	55.0
	Skewness	2.0	1.5	1.4	0.8	-0.7
	Standard Deviation	38.8	48.9	50.1	71.2	25.1
Pilibanga (492)	Coefficient of variation	0.5	0.6	0.5	0.4	0.4
	Kurtosis	1.3	2.3	2.6	-0.5	-0.8
	Maximum, mm	108.0	151.8	174.7	132.0	115.0
	Mean, mm	44.2	52.6	62.6	67.5	62.9
	Median, mm	38.1	45.4	53.0	65.2	57.9
	Minimum, mm	0.0	14.5	27.0	32.0	37.0
	Skewness	1.0	1.5	1.6	0.7	0.8
	Standard Deviation	20.3	29.3	32.6	29.4	26.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Raisinghnagar (495)	Coefficient of variation	0.6	0.7	0.6	0.7	0.4
	Kurtosis	1.1	2.3	1.4	-1.3	-2.8
	Maximum, mm	148.0	174.0	174.0	158.0	99.0
	Mean, mm	49.5	47.6	59.0	73.6	76.5
	Median, mm	44.5	36.8	50.0	62.0	76.5
	Minimum, mm	10.2	5.0	12.0	15.5	54.0
	Skewness	1.0	1.5	1.2	0.4	0.0
	Standard Deviation	28.2	34.8	34.2	48.3	31.8
Sadulshahar (496)	Coefficient of variation	0.6	0.6	0.5	0.6	0.8
	Kurtosis	2.1	1.1	0.2	-1.5	-2.3
	Maximum, mm	187.0	200.0	203.0	149.0	152.0
	Mean, mm	64.3	71.1	83.0	81.0	82.7
	Median, mm	56.5	61.6	75.5	77.0	84.0
	Minimum, mm	16.0	6.3	28.2	10.0	12.0
	Skewness	1.5	1.1	0.9	0.1	0.0
	Standard Deviation	36.9	43.8	43.9	45.9	70.0
Sangriya (497)	Coefficient of variation	0.5	0.5	0.5	0.6	0.5
	Kurtosis	0.0	0.7	-0.3	-1.3	-2.2
	Maximum, mm	147.0	167.8	185.6	196.9	164.0
	Mean, mm	58.9	68.7	78.0	90.3	106.6
	Median, mm	55.0	67.7	73.4	58.6	102.6
	Minimum, mm	7.9	10.1	10.2	13.8	57.0
	Skewness	0.6	0.8	0.5	0.4	0.1
	Standard Deviation	31.0	37.4	42.0	55.6	49.4
Srikaranpur (481)	Coefficient of variation	0.6	0.8	0.6	0.9	1.2
	Kurtosis	3.5	5.0	4.8	-1.2	-2.8
	Maximum, mm	175.0	243.0	250.2	256.2	258.5
	Mean, mm	54.6	56.9	68.7	93.9	138.2
	Median, mm	49.5	41.0	58.5	62.0	138.2
	Minimum, mm	13.5	7.0	14.0	13.0	18.0
	Skewness	1.7	2.0	1.9	0.8	0.0
	Standard Deviation	33.1	45.6	44.0	89.0	170.1

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sunderpura * (504)	Coefficient of variation	0.7	0.6	0.6	0.7	0.5
	Kurtosis	-0.7	-0.6	-0.2	-1.4	-2.3
	Maximum, mm	120.0	147.0	180.9	180.9	85.0
	Mean, mm	47.7	62.7	72.2	86.7	62.7
	Median, mm	42.0	58.0	59.0	74.0	74.0
	Minimum, mm	0.0	0.1	0.1	7.1	29.0
	Skewness	0.3	0.6	0.8	0.3	-0.3
	Standard Deviation	31.0	40.4	43.7	57.4	29.7
Suratgarh (502)	Coefficient of variation	0.6	0.6	0.6	0.5	0.5
	Kurtosis	1.4	-0.1	0.4	0.1	-1.5
	Maximum, mm	140.0	142.0	188.0	193.0	196.0
	Mean, mm	46.9	53.8	64.7	93.1	108.4
	Median, mm	42.5	45.5	48.0	87.8	90.9
	Minimum, mm	0.0	7.0	9.0	45.8	46.9
	Skewness	1.1	0.8	0.8	1.0	0.5
	Standard Deviation	27.5	32.6	38.2	42.7	54.3
T.a. Singh * (507)	Coefficient of variation	0.7	0.7	0.8	0.6	0.7
	Kurtosis	0.4	1.8	4.5	0.3	-1.3
	Maximum, mm	179.6	280.9	358.7	242.0	245.0
	Mean, mm	63.9	84.5	96.0	95.6	108.9
	Median, mm	57.5	69.5	78.5	92.0	69.0
	Minimum, mm	0.0	17.0	25.0	34.0	37.0
	Skewness	0.9	1.5	2.1	1.1	0.7
	Standard Deviation	42.6	60.4	73.7	58.9	76.4
Tibbi (508)	Coefficient of variation	0.6	0.5	0.5	0.5	0.4
	Kurtosis	0.3	0.2	-0.2	-0.5	-1.2
	Maximum, mm	150.0	191.0	191.0	173.0	108.0
	Mean, mm	54.8	73.0	84.4	83.9	87.2
	Median, mm	49.0	67.0	77.0	80.0	107.1
	Minimum, mm	0.0	0.1	0.1	20.0	29.0
	Skewness	0.5	0.8	0.6	0.6	-0.9
	Standard Deviation	32.8	39.4	43.5	43.1	34.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
ACZ Ic						
Bikaner (445)	Coefficient of variation	0.4	0.5	0.4	0.5	0.3
	Kurtosis	0.8	-0.6	-0.8	-1.1	-1.9
	Maximum, mm	126.0	120.0	136.2	116.6	120.0
	Mean, mm	53.3	55.3	69.6	65.8	84.7
	Median, mm	48.5	52.5	66.0	59.3	77.7
	Minimum, mm	7.0	6.1	7.0	16.0	57.6
	Skewness	0.7	0.2	0.1	-0.1	0.2
	Standard Deviation	23.1	27.6	29.5	30.9	26.1
Bikaner (a) (444)	Coefficient of variation	0.4	0.5	0.4	0.6	0.5
	Kurtosis	0.5	-0.8	-0.5	0.5	-1.1
	Maximum, mm	127.2	127.6	154.0	201.8	121.8
	Mean, mm	54.9	61.4	72.5	72.5	66.0
	Median, mm	52.4	52.2	61.5	57.0	58.0
	Minimum, mm	11.2	7.4	11.2	16.0	26.2
	Skewness	0.6	0.5	0.5	1.1	0.6
	Standard Deviation	22.9	29.5	32.3	46.2	31.0
Jaisalmer (511)	Coefficient of variation	0.7	0.8	0.8	0.7	0.6
	Kurtosis	3.7	1.0	1.8	-1.4	-1.7
	Maximum, mm	208.0	229.0	236.0	265.1	267.6
	Mean, mm	54.1	67.7	71.8	117.2	134.6
	Median, mm	41.5	49.0	50.5	88.3	111.4
	Minimum, mm	10.2	2.4	10.2	18.0	54.0
	Skewness	1.9	1.3	1.6	0.6	0.4
	Standard Deviation	40.3	53.9	55.4	83.7	85.8
Jaisalmer (a) (510)	Coefficient of variation	0.8	0.8	0.8	0.7	0.5
	Kurtosis	3.2	1.1	1.9	-0.6	-1.8
	Maximum, mm	204.0	231.8	264.1	267.9	167.6
	Mean, mm	54.5	69.9	72.4	107.5	98.0
	Median, mm	41.3	54.9	50.8	72.5	81.9
	Minimum, mm	0.0	0.5	11.2	22.4	52.4
	Skewness	1.9	1.3	1.6	0.8	0.3
	Standard Deviation	45.2	55.7	58.4	73.5	44.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kolayat (447)	Coefficient of variation	0.5	0.6	0.5	0.5	0.6
	Kurtosis	0.5	0.2	-0.1	-1.1	-2.8
	Maximum, mm	138.0	170.0	170.0	177.0	196.0
	Mean, mm	54.2	62.9	73.3	93.1	141.0
	Median, mm	54.5	52.5	63.9	69.2	141.0
	Minimum, mm	13.0	5.8	17.0	52.0	86.0
	Skewness	0.6	0.9	0.8	0.8	0.0
	Standard Deviation	25.2	40.3	38.4	45.7	77.8
Lunkaransar (446)	Coefficient of variation	0.6	0.9	0.8	0.6	0.5
	Kurtosis	8.3	21.9	20.5	1.5	-0.9
	Maximum, mm	233.0	433.0	433.0	201.0	226.5
	Mean, mm	61.4	68.0	79.0	71.1	109.1
	Median, mm	55.8	56.0	67.9	64.9	86.0
	Minimum, mm	19.0	7.3	24.0	10.3	53.0
	Skewness	2.2	4.2	4.0	1.3	0.8
	Standard Deviation	35.1	61.3	59.5	42.8	59.4
Nokha (449)	Coefficient of variation	0.4	0.6	0.5	0.6	0.5
	Kurtosis	0.6	1.7	1.3	-0.1	-0.5
	Maximum, mm	134.0	206.0	215.0	223.0	227.0
	Mean, mm	57.5	68.2	81.0	86.7	106.0
	Median, mm	56.0	61.0	70.4	76.8	103.0
	Minimum, mm	21.0	8.4	24.0	15.0	32.2
	Skewness	0.8	1.3	1.2	0.9	0.6
	Standard Deviation	24.4	39.9	42.7	55.6	55.5
Sujangarh (456)	Coefficient of variation	0.4	0.5	0.5	0.6	0.5
	Kurtosis	3.1	6.2	2.4	-0.5	-1.1
	Maximum, mm	209.5	329.8	329.8	274.5	289.5
	Mean, mm	76.6	95.9	113.7	113.9	138.8
	Median, mm	67.3	85.8	108.5	99.0	137.0
	Minimum, mm	25.0	11.0	25.0	13.5	14.5
	Skewness	1.4	1.7	1.3	0.7	0.1
	Standard Deviation	32.8	50.7	57.1	66.5	75.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Surpura * (526)	Coefficient of variation	0.5	0.6	0.6	0.5	0.4
	Kurtosis	-1.1	0.7	0.0	-1.0	-1.6
	Maximum, mm	102.0	193.0	209.0	211.0	201.0
	Mean, mm	50.6	67.1	75.6	108.7	138.2
	Median, mm	48.0	53.3	71.0	107.0	139.0
	Minimum, mm	13.0	5.0	15.2	9.9	61.0
	Skewness	0.4	1.1	0.9	0.2	-0.1
	Standard Deviation	25.5	43.0	48.1	55.1	50.5
ACZ IIa						
Chirawa (435)	Coefficient of variation	0.5	0.6	0.6	0.7	0.5
	Kurtosis	1.3	7.7	10.2	9.4	-1.4
	Maximum, mm	183.4	358.7	452.2	460.4	213.0
	Mean, mm	70.8	90.1	110.9	112.3	116.6
	Median, mm	64.2	84.9	97.9	98.6	103.6
	Minimum, mm	19.0	5.0	31.8	27.8	40.0
	Skewness	1.1	2.2	2.6	2.6	0.3
	Standard Deviation	33.8	56.9	67.1	75.7	55.8
Churu (451)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	7.6	4.2	5.5	5.3	4.4
	Maximum, mm	210.0	217.0	271.5	311.5	315.5
	Mean, mm	65.6	74.4	87.6	88.5	106.8
	Median, mm	59.3	71.0	79.5	79.0	93.6
	Minimum, mm	21.0	24.0	25.0	13.0	43.0
	Skewness	2.4	1.7	2.0	1.8	2.0
	Standard Deviation	31.1	37.4	42.8	55.9	60.3
Churu (a) (450)	Coefficient of variation	0.5	0.5	0.5	0.7	0.7
	Kurtosis	7.7	5.0	7.9	10.9	6.1
	Maximum, mm	210.0	231.3	300.4	366.5	370.4
	Mean, mm	66.1	77.0	88.4	87.5	101.3
	Median, mm	57.6	64.6	76.2	76.7	94.6
	Minimum, mm	30.0	33.2	33.2	14.8	18.1
	Skewness	2.5	2.1	2.5	2.9	2.2
	Standard Deviation	32.9	40.9	47.0	62.1	72.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dantaramgarh (432)	Coefficient of variation	0.6	0.6	0.6	0.6	0.6
	Kurtosis	0.7	0.2	0.2	-0.1	-0.2
	Maximum, mm	197.0	260.0	283.0	288.0	328.0
	Mean, mm	76.8	97.8	113.4	111.9	131.6
	Median, mm	67.3	76.4	98.0	89.0	114.5
	Minimum, mm	20.0	25.0	35.5	21.5	35.0
	Skewness	1.2	1.1	1.0	1.0	0.9
	Standard Deviation	43.9	58.9	64.0	72.6	81.4
Degana (339)	Coefficient of variation	0.7	0.8	0.7	0.9	1.0
	Kurtosis	3.3	2.2	2.9	5.9	4.4
	Maximum, mm	281.0	344.0	400.0	554.0	634.0
	Mean, mm	79.6	98.5	115.5	115.7	144.7
	Median, mm	57.0	76.0	91.5	80.1	105.0
	Minimum, mm	21.0	5.6	21.0	26.0	37.0
	Skewness	1.9	1.7	1.8	2.2	2.1
	Standard Deviation	57.1	78.7	83.8	107.1	140.2
Fatehpur (532)	Coefficient of variation	0.6	0.6	0.6	0.9	0.8
	Kurtosis	5.5	4.2	10.1	7.2	3.6
	Maximum, mm	258.0	340.0	474.0	484.0	485.0
	Mean, mm	74.9	94.2	111.1	105.7	141.9
	Median, mm	61.0	80.0	88.0	88.8	125.8
	Minimum, mm	30.0	15.0	35.0	17.0	26.0
	Skewness	2.2	1.8	2.7	2.4	1.9
	Standard Deviation	42.3	59.2	71.5	91.0	111.4
Jhunjhunu (436)	Coefficient of variation	0.4	0.4	0.5	0.6	0.6
	Kurtosis	0.2	5.8	12.4	7.6	6.2
	Maximum, mm	125.0	230.0	317.0	342.0	344.0
	Mean, mm	60.0	76.0	87.4	90.3	106.1
	Median, mm	58.2	74.0	83.5	79.0	86.1
	Minimum, mm	27.0	21.0	39.1	20.0	36.0
	Skewness	0.6	1.8	2.9	2.4	2.4
	Standard Deviation	21.4	34.2	43.2	58.4	64.1

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Khetri (420)	Coefficient of variation	0.5	0.6	0.6	0.7	0.6
	Kurtosis	2.0	3.0	5.0	3.8	1.5
	Maximum, mm	231.0	334.0	413.0	450.0	273.2
	Mean, mm	86.8	107.9	124.9	132.8	106.5
	Median, mm	77.0	89.7	108.6	109.2	92.8
	Minimum, mm	31.2	28.4	33.0	35.6	19.0
	Skewness	1.4	1.7	2.1	2.0	1.3
	Standard Deviation	40.9	62.6	72.7	86.9	59.1
Ladnu (529)	Coefficient of variation	0.6	0.6	0.5	0.5	0.6
	Kurtosis	6.1	3.0	1.1	0.2	-0.1
	Maximum, mm	262.1	293.3	293.3	278.0	321.4
	Mean, mm	72.1	93.2	107.8	116.4	123.3
	Median, mm	58.9	80.0	91.6	99.5	109.4
	Minimum, mm	24.2	19.0	30.0	15.4	20.0
	Skewness	2.2	1.6	1.2	0.9	0.7
	Standard Deviation	42.3	53.5	57.6	59.9	78.7
Laxmangarh (533)	Coefficient of variation	0.7	0.8	0.7	0.7	0.6
	Kurtosis	12.4	8.1	8.5	4.4	2.3
	Maximum, mm	335.3	407.9	458.7	388.0	396.0
	Mean, mm	76.0	89.5	107.9	112.7	133.9
	Median, mm	63.5	71.0	95.5	93.5	127.0
	Minimum, mm	27.0	12.0	36.0	22.0	23.0
	Skewness	3.1	2.6	2.7	1.8	1.4
	Standard Deviation	49.5	69.3	76.0	73.6	84.7
Nawa (430)	Coefficient of variation	0.9	0.9	0.8	0.9	0.9
	Kurtosis	12.8	7.5	7.6	3.0	0.2
	Maximum, mm	457.2	529.1	571.3	427.2	429.7
	Mean, mm	82.7	105.6	120.4	105.5	135.8
	Median, mm	63.3	78.0	90.5	70.8	81.0
	Minimum, mm	24.0	20.0	33.0	10.0	24.0
	Skewness	3.2	2.5	2.6	1.9	1.3
	Standard Deviation	70.9	91.5	97.6	96.4	123.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Neem Ka Thana (421)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	0.6	2.6	2.6	1.2	-0.3
	Maximum, mm	193.0	323.0	383.0	386.0	353.0
	Mean, mm	80.9	99.2	123.2	131.0	155.7
	Median, mm	65.0	82.5	106.8	108.0	141.0
	Minimum, mm	35.0	14.0	37.0	22.0	44.5
	Skewness	1.3	1.6	1.6	1.3	0.8
	Standard Deviation	42.9	62.2	72.5	84.0	85.7
Parbatsar (431)	Coefficient of variation	0.6	0.7	0.7	0.7	0.8
	Kurtosis	-0.1	2.3	1.5	2.3	1.7
	Maximum, mm	177.0	329.0	330.6	406.8	462.2
	Mean, mm	67.9	89.5	103.4	117.4	130.8
	Median, mm	50.8	65.2	80.8	88.0	112.0
	Minimum, mm	15.0	14.0	15.0	23.0	24.5
	Skewness	0.9	1.5	1.4	1.5	1.4
	Standard Deviation	39.9	66.8	72.5	83.6	104.3
Pilani (a) (437)	Coefficient of variation	0.5	0.7	0.7	0.9	0.9
	Kurtosis	5.5	15.9	15.9	11.6	7.3
	Maximum, mm	223.2	402.6	469.6	508.6	513.2
	Mean, mm	68.3	82.0	99.0	97.7	113.8
	Median, mm	61.9	78.2	92.3	80.0	106.0
	Minimum, mm	20.0	18.8	22.5	2.0	19.6
	Skewness	2.0	3.5	3.5	3.0	2.5
	Standard Deviation	37.0	59.9	69.3	86.8	101.3
Ramgarh Shethan (433)	Coefficient of variation	0.5	0.6	0.6	0.9	0.7
	Kurtosis	2.6	3.5	6.4	4.0	-0.7
	Maximum, mm	196.0	270.0	347.0	385.0	211.0
	Mean, mm	64.7	76.3	91.1	93.0	86.6
	Median, mm	58.0	60.0	77.5	68.0	57.0
	Minimum, mm	19.0	22.0	22.0	16.0	5.7
	Skewness	1.5	1.7	2.2	2.0	0.8
	Standard Deviation	35.6	49.0	57.9	82.0	62.4

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Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sikar (535)	Coefficient of variation	0.6	0.7	0.6	0.7	0.7
	Kurtosis	0.3	0.8	1.9	0.4	0.1
	Maximum, mm	236.0	343.0	411.0	414.0	424.6
	Mean, mm	88.2	110.4	130.8	141.0	145.9
	Median, mm	75.3	93.8	109.8	110.0	120.0
	Minimum, mm	18.0	15.0	28.0	21.0	20.4
	Skewness	1.0	1.1	1.4	1.1	1.0
	Standard Deviation	49.9	73.4	81.3	98.1	101.5
Sikar * (534)	Coefficient of variation	0.6	0.6	0.6	0.6	0.6
	Kurtosis	-0.3	0.7	1.2	0.0	-0.1
	Maximum, mm	212.0	342.8	410.8	413.9	413.9
	Mean, mm	86.8	117.0	134.4	154.8	164.8
	Median, mm	70.0	87.5	106.1	117.2	147.5
	Minimum, mm	25.1	16.6	25.1	23.9	22.0
	Skewness	1.0	1.1	1.3	0.9	0.8
	Standard Deviation	49.6	75.4	87.2	99.9	104.9
Udaipur Wati (422)	Coefficient of variation	0.6	0.5	0.5	0.5	0.4
	Kurtosis	6.1	5.4	4.4	0.6	-0.2
	Maximum, mm	279.0	328.0	355.0	278.4	250.6
	Mean, mm	79.0	98.9	114.3	123.7	131.2
	Median, mm	71.0	86.4	99.6	109.8	128.0
	Minimum, mm	0.0	32.0	40.0	44.6	47.0
	Skewness	2.0	2.0	1.8	1.1	0.7
	Standard Deviation	44.2	52.8	57.8	57.4	54.8
ACZ IIb						
Ahore (391)	Coefficient of variation	0.6	0.6	0.6	0.6	0.6
	Kurtosis	1.9	1.2	1.3	0.0	-0.5
	Maximum, mm	236.0	311.0	352.0	361.5	314.0
	Mean, mm	81.6	102.7	118.5	139.1	128.3
	Median, mm	73.2	81.3	90.4	104.0	91.4
	Minimum, mm	20.4	16.6	29.0	30.7	35.0
	Skewness	1.4	1.3	1.4	1.0	0.9
	Standard Deviation	45.0	65.5	76.0	90.1	83.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bali (561)	Coefficient of variation	0.6	0.6	0.7	0.8	0.9
	Kurtosis	4.7	4.8	7.1	7.3	4.5
	Maximum, mm	350.0	522.0	654.8	708.8	714.0
	Mean, mm	101.8	140.9	159.0	154.4	162.8
	Median, mm	83.9	110.0	123.9	127.0	119.7
	Minimum, mm	30.0	44.0	51.0	14.5	17.5
	Skewness	1.9	2.0	2.3	2.3	2.1
	Standard Deviation	58.9	89.6	105.5	121.8	148.9
Baniawas * (363)	Coefficient of variation	1.0	1.2	1.3	1.4	1.6
	Kurtosis	1.2	5.1	7.6	6.9	6.3
	Maximum, mm	255.0	495.0	702.0	748.0	777.0
	Mean, mm	70.9	93.8	114.2	110.3	113.5
	Median, mm	59.0	61.8	74.6	60.0	67.0
	Minimum, mm	1.1	1.9	1.9	2.8	1.3
	Skewness	1.4	2.3	2.7	2.5	2.5
	Standard Deviation	68.6	111.9	149.8	158.4	176.5
Bilara (355)	Coefficient of variation	0.6	0.7	0.7	0.9	1.1
	Kurtosis	5.6	6.9	11.2	14.4	6.8
	Maximum, mm	300.0	454.0	582.0	704.5	762.5
	Mean, mm	83.3	105.5	122.1	129.5	150.0
	Median, mm	68.6	92.3	107.5	93.0	97.0
	Minimum, mm	28.0	8.0	31.0	24.0	22.0
	Skewness	2.2	2.3	2.9	3.5	2.5
	Standard Deviation	52.9	77.8	89.5	114.4	162.4
Danta * (409)	Coefficient of variation	0.6	0.7	0.6	0.7	0.7
	Kurtosis	2.5	2.0	2.4	2.7	2.2
	Maximum, mm	280.0	393.0	431.0	471.0	495.0
	Mean, mm	88.1	114.3	133.1	137.1	152.2
	Median, mm	83.5	93.2	109.6	114.0	118.2
	Minimum, mm	14.9	16.1	20.7	16.7	23.3
	Skewness	1.4	1.4	1.6	1.6	1.6
	Standard Deviation	51.8	78.0	84.1	95.4	104.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Desuri (374)	Coefficient of variation	0.6	0.6	0.5	0.7	0.7
	Kurtosis	0.6	0.2	0.3	0.0	0.4
	Maximum, mm	284.0	360.0	388.6	413.7	427.7
	Mean, mm	106.0	143.2	160.3	163.2	161.1
	Median, mm	91.1	118.7	130.5	136.5	133.6
	Minimum, mm	35.6	41.9	43.0	22.0	24.0
	Skewness	1.1	1.0	1.0	0.9	1.2
	Standard Deviation	59.4	79.3	87.3	106.7	109.4
Girinanda * (341)	Coefficient of variation	0.6	0.7	0.6	0.8	0.8
	Kurtosis	4.2	4.0	3.2	9.1	8.0
	Maximum, mm	250.0	344.0	374.0	496.0	518.0
	Mean, mm	68.4	90.9	106.7	110.6	122.0
	Median, mm	60.2	73.8	86.0	82.0	89.4
	Minimum, mm	16.0	27.5	16.0	30.0	19.6
	Skewness	1.8	1.9	1.7	2.7	2.6
	Standard Deviation	43.7	62.6	67.3	84.6	95.2
Hemawas * (371)	Coefficient of variation	0.8	0.8	0.9	1.0	0.7
	Kurtosis	2.9	7.0	13.7	12.1	1.1
	Maximum, mm	350.0	550.0	750.0	810.0	415.2
	Mean, mm	86.9	116.4	130.7	143.3	135.6
	Median, mm	60.8	85.6	103.0	109.0	112.9
	Minimum, mm	7.0	22.0	7.0	33.1	36.0
	Skewness	1.6	2.3	3.2	3.2	1.4
	Standard Deviation	67.0	93.5	114.6	137.4	100.0
Jaitaran (348)	Coefficient of variation	0.6	0.7	0.7	0.9	1.0
	Kurtosis	2.0	5.0	8.6	14.3	10.4
	Maximum, mm	226.0	381.0	494.0	602.0	659.0
	Mean, mm	75.6	99.2	112.2	103.7	122.5
	Median, mm	63.3	79.6	84.0	70.0	82.0
	Minimum, mm	19.0	26.0	29.0	22.6	30.0
	Skewness	1.5	2.1	2.6	3.5	3.0
	Standard Deviation	42.8	70.8	81.2	97.6	121.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Jalore (543)	Coefficient of variation	0.6	0.7	0.7	0.7	0.7
	Kurtosis	2.5	5.7	6.8	5.7	3.2
	Maximum, mm	268.0	429.0	499.4	548.2	548.8
	Mean, mm	86.4	108.3	122.4	131.0	155.5
	Median, mm	74.7	88.5	94.1	108.2	120.4
	Minimum, mm	12.0	8.4	12.1	11.2	26.7
	Skewness	1.5	2.0	2.2	2.0	1.7
	Standard Deviation	49.3	71.3	80.5	95.7	109.3
Jaswant Sagar * (353)	Coefficient of variation	0.7	0.8	0.8	1.0	1.0
	Kurtosis	3.6	6.3	9.7	11.0	6.8
	Maximum, mm	273.1	451.5	580.1	702.3	760.3
	Mean, mm	84.5	98.9	120.2	134.5	165.6
	Median, mm	69.0	73.8	100.1	105.8	113.4
	Minimum, mm	25.0	7.0	25.0	22.6	36.7
	Skewness	2.0	2.2	2.7	3.1	2.6
	Standard Deviation	57.1	79.0	91.7	127.9	161.5
Jaswantpura (413)	Coefficient of variation	0.7	0.7	0.7	0.7	0.6
	Kurtosis	2.5	0.5	1.6	-0.1	-0.2
	Maximum, mm	325.0	353.9	470.0	475.0	510.0
	Mean, mm	103.2	131.1	147.4	165.4	198.4
	Median, mm	81.2	110.0	123.5	126.0	150.8
	Minimum, mm	20.0	19.6	38.0	26.2	53.0
	Skewness	1.7	1.2	1.5	1.0	0.9
	Standard Deviation	67.4	89.8	96.5	116.4	119.3
Jograwas * (365)	Coefficient of variation	1.0	1.2	1.5	1.4	1.4
	Kurtosis	3.2	8.7	12.0	8.1	6.9
	Maximum, mm	250.4	490.8	693.9	710.6	738.0
	Mean, mm	59.4	79.8	92.7	109.9	118.2
	Median, mm	48.0	56.9	58.4	69.1	75.0
	Minimum, mm	0.8	1.6	1.6	2.5	1.3
	Skewness	1.8	2.9	3.4	2.8	2.7
	Standard Deviation	57.7	98.8	134.6	155.4	168.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kana * (379)	Coefficient of variation	0.6	0.6	0.7	0.7	0.7
	Kurtosis	2.4	1.0	2.6	3.4	6.0
	Maximum, mm	225.0	270.0	348.0	412.0	462.0
	Mean, mm	72.0	95.8	110.0	116.7	120.8
	Median, mm	59.7	80.2	88.5	90.1	97.6
	Minimum, mm	15.0	17.6	17.6	15.6	22.5
	Skewness	1.6	1.2	1.6	1.8	2.2
	Standard Deviation	44.3	60.9	72.5	82.9	82.1
Kharda * (375)	Coefficient of variation	0.8	1.0	1.0	1.2	1.3
	Kurtosis	3.1	7.4	10.1	5.8	0.7
	Maximum, mm	288.0	538.0	673.0	733.0	742.0
	Mean, mm	81.0	108.4	123.3	140.9	186.9
	Median, mm	70.0	82.0	92.2	97.5	100.1
	Minimum, mm	6.0	18.2	8.0	10.3	18.8
	Skewness	1.9	2.6	3.0	2.5	1.6
	Standard Deviation	66.8	107.4	127.8	171.1	249.2
Meli Tank * (349)	Coefficient of variation	0.8	0.8	0.8	1.0	1.2
	Kurtosis	14.2	6.9	5.6	7.3	2.5
	Maximum, mm	360.7	373.7	385.3	559.7	645.7
	Mean, mm	66.7	84.7	94.4	109.9	142.6
	Median, mm	51.5	71.0	71.9	75.6	60.0
	Minimum, mm	17.5	4.0	17.5	29.0	12.9
	Skewness	3.3	2.5	2.2	2.7	1.9
	Standard Deviation	54.0	70.3	75.3	112.6	168.7
Muthana * (380)	Coefficient of variation	0.7	0.7	0.7	0.8	0.9
	Kurtosis	1.1	1.1	2.9	6.4	7.3
	Maximum, mm	226.0	289.0	381.0	472.0	529.0
	Mean, mm	71.0	93.9	109.2	108.3	114.4
	Median, mm	58.0	78.1	90.9	95.4	96.0
	Minimum, mm	11.9	15.2	16.4	16.6	15.6
	Skewness	1.2	1.2	1.6	2.2	2.4
	Standard Deviation	48.5	64.6	78.0	84.9	98.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Ora * (410)	.Coefficient of variation	0.7	0.8	0.8	0.9	1.0
	Kurtosis	2.0	5.6	6.9	5.4	9.9
	Maximum, mm	268.0	478.0	560.0	616.0	637.0
	Mean, mm	76.7	104.3	119.4	126.2	116.5
	Median, mm	66.2	78.0	92.0	83.0	87.5
	Minimum, mm	11.4	12.5	13.0	8.7	11.8
	Skewness	1.2	2.0	2.2	2.1	2.8
	Standard Deviation	50.6	83.4	94.0	116.9	114.6
Pali (372)	Coefficient of variation	0.8	0.8	0.8	0.9	1.1
	Kurtosis	4.1	4.5	6.8	6.9	3.8
	Maximum, mm	357.0	490.8	590.8	629.8	631.9
	Mean, mm	87.9	114.4	124.8	125.8	129.7
	Median, mm	65.0	82.5	94.5	89.0	67.4
	Minimum, mm	22.0	5.0	26.0	19.0	15.8
	Skewness	2.0	2.0	2.4	2.4	2.0
	Standard Deviation	68.3	92.6	102.2	117.0	144.4
Raipur (359)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	0.7	-0.7	0.1	2.2	2.1
	Maximum, mm	226.0	241.0	309.0	386.0	392.0
	Mean, mm	84.8	112.6	129.2	125.6	123.8
	Median, mm	76.1	101.4	109.5	106.8	98.2
	Minimum, mm	25.0	5.2	25.0	41.5	44.2
	Skewness	1.0	0.6	0.9	1.5	1.4
	Standard Deviation	44.6	60.6	66.8	76.3	77.6
Raipur Luni * (360)	Coefficient of variation	0.6	0.7	0.7	0.8	0.8
	Kurtosis	2.0	1.7	1.5	2.0	1.8
	Maximum, mm	230.8	325.5	357.4	387.4	468.0
	Mean, mm	73.1	96.8	115.2	119.4	130.5
	Median, mm	57.0	71.9	93.0	80.2	83.8
	Minimum, mm	14.7	15.6	17.1	27.0	18.0
	Skewness	1.4	1.5	1.5	1.7	1.6
	Standard Deviation	47.4	67.5	82.5	95.5	109.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Reodhar * (548)	Coefficient of variation	0.6	0.6	0.7	0.7	0.7
	Kurtosis	2.3	3.9	5.6	5.0	3.6
	Maximum, mm	317.0	484.7	608.7	637.7	648.7
	Mean, mm	106.1	144.4	164.2	177.3	188.9
	Median, mm	85.8	117.3	129.2	141.0	148.8
	Minimum, mm	27.6	16.5	27.6	21.4	20.0
	Skewness	1.6	1.9	2.3	2.2	1.9
	Standard Deviation	63.1	89.5	110.3	118.7	131.9
Sadri * (382)	Coefficient of variation	0.5	0.6	0.6	0.6	0.7
	Kurtosis	-0.1	5.0	4.9	6.6	5.7
	Maximum, mm	196.1	388.1	431.0	471.1	491.2
	Mean, mm	77.5	108.7	124.1	124.1	132.8
	Median, mm	65.5	98.9	116.2	114.4	115.1
	Minimum, mm	18.1	25.0	29.0	31.5	32.1
	Skewness	0.8	1.7	1.8	2.2	2.2
	Standard Deviation	41.9	63.5	71.3	79.6	93.9
Sanderao * (388)	Coefficient of variation	0.5	0.6	0.6	0.7	0.7
	Kurtosis	0.0	2.1	1.1	1.3	1.3
	Maximum, mm	172.9	297.6	314.6	327.8	370.1
	Mean, mm	73.5	99.7	114.1	114.4	116.4
	Median, mm	60.4	81.3	88.9	98.1	97.4
	Minimum, mm	22.6	24.0	32.8	10.9	12.0
	Skewness	0.9	1.5	1.3	1.2	1.2
	Standard Deviation	38.2	63.5	72.8	74.4	84.2
Sardar Samand * (361)	Coefficient of variation	0.7	0.9	0.9	1.0	1.1
	Kurtosis	3.6	8.2	12.9	11.7	9.6
	Maximum, mm	269.4	473.7	608.2	658.2	668.0
	Mean, mm	69.9	89.3	107.1	111.7	121.4
	Median, mm	58.0	56.9	83.4	91.6	88.9
	Minimum, mm	5.1	1.2	5.1	13.9	13.3
	Skewness	1.7	2.4	3.0	3.1	3.0
	Standard Deviation	51.2	79.1	93.5	112.2	129.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sheoganj * (547)	Coefficient of variation	0.5	0.6	0.6	0.7	0.7
	Kurtosis	3.8	3.0	3.2	4.0	8.8
	Maximum, mm	315.4	446.4	467.4	520.2	592.0
	Mean, mm	99.6	133.6	149.2	142.3	138.4
	Median, mm	92.4	114.5	127.2	118.1	121.1
	Minimum, mm	28.4	25.4	43.0	14.2	30.9
	Skewness	1.6	1.4	1.6	1.7	2.6
	Standard Deviation	52.2	77.8	83.4	96.8	103.0
Sirohi (411)	Coefficient of variation	0.6	0.6	0.6	0.7	0.8
	Kurtosis	-0.2	2.5	2.7	3.6	4.1
	Maximum, mm	272.0	531.0	582.0	628.0	674.0
	Mean, mm	113.0	152.0	172.6	159.1	170.6
	Median, mm	96.5	128.8	147.8	126.2	129.0
	Minimum, mm	27.9	27.1	39.4	20.6	33.4
	Skewness	0.8	1.3	1.5	1.7	1.9
	Standard Deviation	62.6	97.3	107.1	118.7	129.1
Siwana (351)	Coefficient of variation	0.6	0.7	0.7	0.9	1.0
	Kurtosis	-0.1	3.7	2.5	3.4	1.1
	Maximum, mm	205.0	369.0	413.0	474.0	530.0
	Mean, mm	83.9	101.1	116.6	124.4	146.8
	Median, mm	72.0	77.0	92.6	100.0	95.5
	Minimum, mm	15.0	23.4	15.0	19.4	21.4
	Skewness	0.9	1.8	1.5	1.9	1.5
	Standard Deviation	48.2	70.0	79.8	110.7	152.1
Sojat (362)	Coefficient of variation	0.7	0.7	0.6	0.6	0.7
	Kurtosis	5.3	4.2	3.2	3.9	5.2
	Maximum, mm	301.8	327.8	356.0	360.3	393.7
	Mean, mm	76.2	93.9	109.8	114.6	108.3
	Median, mm	60.0	77.0	88.7	100.4	84.2
	Minimum, mm	14.0	19.6	22.3	43.4	40.0
	Skewness	2.2	2.0	1.7	1.9	2.1
	Standard Deviation	53.5	63.7	70.7	70.1	72.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Takhatgarh * (389)	Coefficient of variation	0.6	0.6	0.6	0.7	0.8
	Kurtosis	3.6	0.9	0.5	-0.2	0.1
	Maximum, mm	228.6	246.9	254.8	271.2	290.0
	Mean, mm	66.4	85.8	98.6	106.6	98.7
	Median, mm	56.7	71.7	82.3	91.3	78.5
	Minimum, mm	18.1	17.8	24.4	9.0	12.1
	Skewness	1.6	1.1	1.0	0.8	1.0
	Standard Deviation	39.0	53.0	58.0	71.3	76.8
ACZ IIIa						
Ajmer (424)	Coefficient of variation	0.6	0.6	0.5	0.7	0.7
	Kurtosis	5.3	3.7	2.2	6.8	5.6
	Maximum, mm	294.0	327.2	338.2	478.2	481.2
	Mean, mm	78.9	101.9	116.5	118.0	124.8
	Median, mm	64.5	88.9	100.6	99.1	99.0
	Minimum, mm	27.4	32.0	33.5	15.2	25.7
	Skewness	2.1	1.9	1.5	2.3	2.2
	Standard Deviation	49.6	57.9	62.1	78.4	83.5
Ajmer (a) (423)	Coefficient of variation	0.6	0.6	0.6	0.7	0.8
	Kurtosis	3.3	1.4	2.9	4.3	3.2
	Maximum, mm	294.0	327.2	417.0	478.2	481.2
	Mean, mm	93.3	120.0	136.8	137.4	136.6
	Median, mm	77.0	103.8	113.0	114.6	95.5
	Minimum, mm	35.4	46.1	53.5	25.3	25.7
	Skewness	1.8	1.4	1.7	2.0	1.9
	Standard Deviation	57.9	66.6	76.8	93.6	106.3
Amber (180)	Coefficient of variation	0.5	0.6	0.6	0.6	0.7
	Kurtosis	3.4	9.5	9.3	5.8	4.3
	Maximum, mm	250.0	430.0	530.0	543.4	569.8
	Mean, mm	88.9	116.0	139.2	144.4	156.8
	Median, mm	80.0	110.9	126.4	123.0	142.4
	Minimum, mm	20.0	33.0	45.0	21.0	34.4
	Skewness	1.6	2.6	2.7	2.1	1.8
	Standard Deviation	42.3	63.9	80.7	91.9	105.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Arain (154)	Coefficient of variation	0.6	0.6	0.5	0.5	0.5
	Kurtosis	1.6	0.5	0.4	0.8	0.0
	Maximum, mm	200.0	247.0	276.0	284.0	283.0
	Mean, mm	74.9	98.3	110.4	119.8	124.4
	Median, mm	66.0	92.5	95.0	111.8	116.4
	Minimum, mm	16.0	19.0	21.0	28.0	20.0
	Skewness	1.4	1.0	0.9	1.0	0.8
	Standard Deviation	42.2	54.7	60.1	60.5	64.5
Bassi (181)	Coefficient of variation	0.9	1.0	0.9	0.9	0.9
	Kurtosis	27.0	29.3	25.6	17.6	15.2
	Maximum, mm	556.0	840.0	855.0	857.0	885.0
	Mean, mm	86.7	114.8	133.2	147.3	159.4
	Median, mm	70.5	94.5	108.5	126.5	146.0
	Minimum, mm	15.0	11.0	16.0	9.0	17.0
	Skewness	4.7	5.0	4.6	3.7	3.4
	Standard Deviation	74.8	113.4	116.4	126.4	136.3
Baswa (220)	Coefficient of variation	0.4	0.5	0.5	0.6	0.5
	Kurtosis	-0.1	0.7	1.4	1.1	-0.2
	Maximum, mm	199.4	276.6	340.6	344.7	346.7
	Mean, mm	88.3	114.2	130.7	124.7	144.0
	Median, mm	75.0	99.5	117.3	109.7	129.5
	Minimum, mm	30.0	28.4	33.0	19.0	30.9
	Skewness	0.8	1.1	1.1	1.2	0.8
	Standard Deviation	39.4	56.2	60.6	71.7	78.1
Beawar * (343)	Coefficient of variation	0.5	0.5	0.5	0.6	0.5
	Kurtosis	1.7	0.8	0.7	-0.2	-0.6
	Maximum, mm	237.5	297.5	327.5	327.8	280.0
	Mean, mm	83.8	107.9	124.7	127.4	122.7
	Median, mm	73.5	97.0	112.5	112.0	118.5
	Minimum, mm	28.0	27.0	31.5	27.0	41.0
	Skewness	1.2	0.9	0.9	0.7	0.6
	Standard Deviation	42.5	55.9	60.6	73.2	64.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bhinai (155)	Coefficient of variation	0.5	0.4	0.4	0.5	0.6
	Kurtosis	1.0	-0.6	0.3	2.3	3.2
	Maximum, mm	177.0	178.0	246.0	257.0	277.0
	Mean, mm	74.1	87.2	106.2	93.7	97.3
	Median, mm	69.5	85.0	97.5	87.4	77.0
	Minimum, mm	21.0	26.4	35.0	21.6	48.0
	Skewness	1.0	0.4	0.7	1.4	1.8
	Standard Deviation	34.2	38.5	46.0	48.3	55.5
Chaksu (182)	Coefficient of variation	0.5	0.7	0.7	0.8	0.8
	Kurtosis	5.1	16.8	20.2	15.8	14.5
	Maximum, mm	290.0	556.0	711.0	748.6	764.2
	Mean, mm	86.4	113.9	132.0	138.2	144.8
	Median, mm	79.0	91.4	113.8	127.0	119.0
	Minimum, mm	24.0	17.2	47.0	18.0	36.0
	Skewness	1.8	3.5	3.9	3.4	3.4
	Standard Deviation	46.6	77.7	97.6	111.3	120.1
Chhaparwara * (165)	Coefficient of variation	0.5	0.5	0.5	0.6	0.7
	Kurtosis	0.1	0.6	0.7	0.7	0.3
	Maximum, mm	167.0	234.0	261.0	277.0	295.6
	Mean, mm	69.6	89.0	104.0	105.3	111.7
	Median, mm	58.2	73.0	91.0	93.2	97.1
	Minimum, mm	13.0	23.0	24.2	23.3	18.4
	Skewness	1.0	1.0	0.9	1.0	0.9
	Standard Deviation	37.6	48.1	53.8	61.5	73.5
Chomu (426)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	0.1	0.2	-0.3	-0.1	-0.4
	Maximum, mm	177.6	264.7	274.0	289.6	314.3
	Mean, mm	76.8	100.6	121.7	119.8	129.4
	Median, mm	65.3	91.5	110.6	106.5	99.8
	Minimum, mm	28.0	31.0	46.8	24.5	17.0
	Skewness	1.0	1.0	0.8	0.8	0.8
	Standard Deviation	37.3	54.1	60.4	66.0	75.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dausa (221)	Coefficient of variation	0.8	0.7	0.7	0.7	0.8
	Kurtosis	27.9	22.6	21.5	12.9	12.3
	Maximum, mm	550.0	645.2	697.6	704.6	791.0
	Mean, mm	92.4	118.2	140.3	149.2	152.9
	Median, mm	76.1	94.3	118.1	126.4	126.0
	Minimum, mm	38.4	21.0	66.2	41.0	18.0
	Skewness	4.9	4.2	4.1	3.1	3.0
	Standard Deviation	71.7	86.7	92.8	104.9	123.7
Galvania Bund * (58)	Coefficient of variation	0.6	0.7	0.6	0.6	0.6
	Kurtosis	2.1	2.1	1.3	0.8	0.8
	Maximum, mm	253.0	320.0	332.0	362.0	387.0
	Mean, mm	78.7	102.7	119.4	136.7	149.0
	Median, mm	69.0	88.0	105.0	129.0	139.5
	Minimum, mm	0.2	0.2	0.2	0.2	0.2
	Skewness	1.4	1.5	1.1	0.8	0.6
	Standard Deviation	50.7	70.7	74.6	78.7	84.6
Galwar * (577)	Coefficient of variation	0.6	0.6	0.6	0.7	0.7
	Kurtosis	1.6	0.2	0.1	-0.4	-0.8
	Maximum, mm	264.0	285.0	332.0	383.0	396.0
	Mean, mm	85.6	107.3	128.7	139.6	155.2
	Median, mm	72.0	88.5	107.0	114.0	123.5
	Minimum, mm	0.2	0.2	0.2	0.2	0.2
	Skewness	1.2	1.0	0.8	0.7	0.6
	Standard Deviation	53.2	69.4	76.3	97.3	107.7
Gegal (156)	Coefficient of variation	0.7	0.7	0.7	0.7	0.8
	Kurtosis	0.3	1.0	1.0	0.0	0.7
	Maximum, mm	197.0	306.0	341.0	378.0	453.0
	Mean, mm	71.5	92.0	108.2	148.0	146.8
	Median, mm	59.0	74.0	88.3	115.0	95.0
	Minimum, mm	8.4	8.1	13.0	42.8	30.9
	Skewness	1.1	1.2	1.1	1.2	1.4
	Standard Deviation	47.6	66.4	70.5	99.8	120.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Goela (157)	Coefficient of variation	0.5	0.5	0.4	0.4	0.5
	Kurtosis	2.5	0.5	-0.1	-0.4	-0.4
	Maximum, mm	184.0	193.0	193.0	174.0	198.6
	Mean, mm	66.4	76.3	91.9	92.8	92.0
	Median, mm	58.5	73.0	86.5	95.0	94.2
	Minimum, mm	24.0	13.0	26.0	23.0	18.0
	Skewness	1.6	0.7	0.6	0.3	0.4
	Standard Deviation	33.3	36.6	37.5	35.8	46.0
Jaipur (184)	Coefficient of variation	0.5	0.5	0.6	0.6	0.6
	Kurtosis	0.5	1.8	5.5	3.5	2.1
	Maximum, mm	193.0	308.0	438.0	464.0	478.8
	Mean, mm	84.8	107.6	129.1	148.3	166.1
	Median, mm	75.0	99.4	116.2	125.4	144.0
	Minimum, mm	23.0	11.0	26.0	23.6	16.1
	Skewness	1.0	1.2	2.0	1.7	1.4
	Standard Deviation	40.0	55.0	72.2	87.3	98.6
Jaipur (a) (185)	Coefficient of variation	0.6	0.6	0.7	0.7	0.8
	Kurtosis	11.5	14.5	17.4	17.7	14.2
	Maximum, mm	385.5	549.1	683.0	795.4	812.6
	Mean, mm	95.1	124.7	145.1	156.6	159.1
	Median, mm	79.8	105.0	136.1	139.9	132.5
	Minimum, mm	33.0	38.9	39.1	42.8	31.5
	Skewness	2.9	3.3	3.7	3.8	3.3
	Standard Deviation	57.9	80.4	98.0	116.1	124.7
Jamwa Ramgarh (222)	Coefficient of variation	0.6	0.6	0.5	0.6	0.6
	Kurtosis	14.3	11.2	9.7	5.7	3.8
	Maximum, mm	408.0	448.0	461.5	479.0	496.5
	Mean, mm	91.2	113.1	131.3	126.4	145.4
	Median, mm	82.0	103.8	124.9	113.0	139.0
	Minimum, mm	30.1	31.6	54.4	19.0	23.0
	Skewness	3.3	2.8	2.5	1.8	1.6
	Standard Deviation	58.6	64.9	65.6	78.6	87.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kanota * (186)	Coefficient of variation	0.9	1.0	1.0	1.0	1.0
	Kurtosis	31.3	30.8	31.3	23.4	20.2
	Maximum, mm	589.2	798.4	919.4	935.0	949.6
	Mean, mm	83.3	105.9	126.4	135.7	140.2
	Median, mm	68.5	85.3	109.3	102.3	107.4
	Minimum, mm	25.2	6.8	39.9	24.0	24.6
	Skewness	5.3	5.2	5.3	4.5	4.1
	Standard Deviation	78.6	108.1	123.3	136.4	144.4
	Kurtosis	0.4	0.7	0.8	1.1	0.2
	Maximum, mm	162.2	239.0	257.0	249.0	281.8
	Mean, mm	76.2	99.2	112.3	107.4	113.1
	Median, mm	68.5	86.0	100.5	103.0	112.0
	Minimum, mm	31.0	21.0	40.0	26.0	30.0
	Skewness	1.0	1.2	1.2	1.1	0.8
	Standard Deviation	33.9	47.9	51.0	49.4	61.0
	Kurtosis	-0.1	-0.5	0.0	0.1	-1.1
	Maximum, mm	193.0	242.0	307.0	336.0	267.0
	Mean, mm	86.4	113.1	132.1	125.0	137.3
	Median, mm	78.0	105.0	120.0	108.4	108.0
	Minimum, mm	27.4	35.1	35.1	13.5	15.8
	Skewness	0.8	0.6	0.7	0.7	0.2
	Standard Deviation	37.9	50.0	59.1	69.6	65.0
	Kurtosis	8.5	11.9	14.0	10.4	8.3
	Maximum, mm	301.0	476.0	572.0	597.0	599.0
	Mean, mm	97.7	133.2	155.9	170.7	176.5
	Median, mm	88.5	119.3	138.1	157.0	157.0
	Minimum, mm	45.0	53.0	55.0	59.5	45.0
	Skewness	2.3	2.8	3.1	2.6	2.4
	Standard Deviation	41.4	64.9	76.2	84.8	90.6
	Kurtosis	1.3	-0.3	0.2	-0.2	-0.5
	Maximum, mm	169.0	209.3	248.6	272.8	274.0
	Mean, mm	69.0	89.8	108.2	123.5	132.5
	Median, mm	60.0	81.0	96.8	120.0	128.4
	Minimum, mm	29.3	10.0	44.0	28.0	32.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
	Skewness	1.3	0.7	1.0	0.5	0.5
	Standard Deviation	33.5	47.7	50.6	58.6	61.7
	Kurtosis	1.3	0.6	2.1	1.6	-0.7
	Maximum, mm	233.4	298.0	373.0	377.0	273.1
	Mean, mm	91.3	113.3	132.5	135.3	129.8
	Median, mm	80.5	98.9	114.0	119.0	123.4
	Minimum, mm	26.0	20.2	40.0	28.0	36.0
	Skewness	1.1	0.9	1.3	1.1	0.5
	Standard Deviation	43.9	62.0	66.0	72.6	64.9
	Kurtosis	2.5	1.2	1.0	0.1	-0.7
	Maximum, mm	237.0	262.0	276.0	281.0	237.0
	Mean, mm	68.4	83.5	93.4	91.5	95.0
	Median, mm	56.0	70.0	76.5	68.0	71.5
	Minimum, mm	17.0	6.5	20.5	18.0	24.0
	Skewness	1.5	1.2	1.2	1.0	0.9
	Standard Deviation	44.3	54.6	56.7	69.8	70.1
	Kurtosis	4.9	8.6	8.8	3.9	0.4
	Maximum, mm	327.0	493.0	518.0	522.0	374.8
	Mean, mm	95.5	118.5	134.9	140.9	152.4
	Median, mm	77.5	96.0	121.7	123.4	142.0
	Minimum, mm	23.0	21.0	27.0	27.0	37.0
	Skewness	2.1	2.6	2.5	1.8	1.0
	Standard Deviation	62.5	81.2	82.6	101.7	89.5
	Kurtosis	0.2	1.4	0.6	0.6	-1.3
	Maximum, mm	215.0	302.0	314.0	321.0	238.0
	Mean, mm	83.3	106.1	118.1	126.6	130.7
	Median, mm	75.0	93.0	99.7	112.2	122.4
	Minimum, mm	27.0	33.0	38.0	41.0	46.8
	Skewness	1.0	1.3	1.0	1.0	0.2
	Standard Deviation	45.9	59.2	62.8	65.4	59.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Moti Sagar * (127)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	0.3	-0.7	-0.3	-0.6	0.4
	Maximum, mm	212.5	231.0	286.0	313.0	345.0
	Mean, mm	84.8	108.1	126.1	133.8	132.0
	Median, mm	85.2	99.3	111.8	119.8	105.1
	Minimum, mm	28.8	15.0	34.2	36.2	45.3
	Skewness	0.8	0.5	0.6	0.6	1.1
	Standard Deviation	41.9	53.5	57.8	68.8	74.0
Naraina (171)	Coefficient of variation	0.6	0.7	0.6	0.7	0.7
	Kurtosis	3.2	2.7	2.4	1.8	1.0
	Maximum, mm	244.0	351.8	369.8	409.8	418.8
	Mean, mm	77.4	98.1	113.5	127.2	152.2
	Median, mm	67.1	84.2	94.9	100.5	109.0
	Minimum, mm	14.2	18.2	18.2	20.7	36.2
	Skewness	1.7	1.5	1.4	1.4	1.4
	Standard Deviation	45.6	67.3	69.5	87.5	100.3
Nasira Bad (159)	Coefficient of variation	0.5	0.5	0.4	0.6	0.5
	Kurtosis	1.1	0.4	0.8	1.8	1.0
	Maximum, mm	180.2	189.2	236.0	296.2	302.0
	Mean, mm	70.5	84.5	100.7	108.5	134.5
	Median, mm	62.5	78.2	95.5	99.0	122.5
	Minimum, mm	17.8	17.0	33.3	22.1	39.0
	Skewness	1.0	0.9	1.0	1.3	1.1
	Standard Deviation	32.0	39.9	43.3	61.0	63.8
Nasirda * (128)	Coefficient of variation	0.4	0.5	0.4	0.5	0.4
	Kurtosis	-0.2	-0.7	-0.7	-0.7	-1.0
	Maximum, mm	156.0	189.8	222.3	246.8	254.0
	Mean, mm	69.7	93.1	108.5	111.8	134.6
	Median, mm	61.0	87.5	105.9	109.6	128.0
	Minimum, mm	17.0	22.0	25.0	34.0	48.9
	Skewness	0.6	0.4	0.3	0.5	0.4
	Standard Deviation	31.0	44.3	46.7	55.1	57.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Niwai (179)	Coefficient of variation	0.5	0.5	0.5	0.6	0.7
	Kurtosis	0.7	0.9	3.1	3.1	3.9
	Maximum, mm	204.0	308.0	424.1	518.7	597.7
	Mean, mm	90.9	121.7	141.2	151.3	165.2
	Median, mm	80.4	111.9	121.4	129.8	126.1
	Minimum, mm	31.0	44.0	44.0	21.5	55.0
	Skewness	1.2	1.1	1.6	1.5	1.8
	Standard Deviation	41.3	59.3	71.2	93.1	111.3
Panwar Sagar * (130)	Coefficient of variation	0.5	0.6	0.5	0.5	0.5
	Kurtosis	1.3	0.3	0.4	0.2	0.1
	Maximum, mm	200.0	233.8	260.0	267.0	286.7
	Mean, mm	77.4	97.5	111.2	117.0	126.9
	Median, mm	66.7	86.6	98.5	106.4	110.9
	Minimum, mm	25.0	25.0	38.0	45.0	50.0
	Skewness	1.4	1.1	1.2	1.1	1.0
	Standard Deviation	38.5	53.9	57.3	61.0	61.5
Paota (263)	Coefficient of variation	0.4	0.5	0.5	0.5	0.5
	Kurtosis	0.3	-0.2	-0.4	-0.9	-1.0
	Maximum, mm	226.0	274.0	330.0	355.0	331.0
	Mean, mm	102.4	129.6	154.5	172.3	181.9
	Median, mm	103.5	122.0	134.5	162.2	162.0
	Minimum, mm	30.0	35.0	57.0	32.0	48.0
	Skewness	0.8	0.7	0.8	0.4	0.4
	Standard Deviation	45.0	58.7	73.8	82.7	84.9
Phagi (173)	Coefficient of variation	0.7	0.8	0.7	0.8	0.9
	Kurtosis	9.0	8.6	7.6	4.4	4.2
	Maximum, mm	354.0	472.0	513.0	543.4	632.4
	Mean, mm	84.8	110.8	124.3	137.9	142.7
	Median, mm	70.0	83.8	94.1	102.5	90.8
	Minimum, mm	32.0	22.0	38.0	17.8	20.4
	Skewness	2.8	2.7	2.5	2.0	2.0
	Standard Deviation	58.8	84.2	90.4	108.5	133.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Phulera (427)	Coefficient of variation	0.5	0.6	0.5	0.7	0.7
	Kurtosis	0.8	1.6	0.9	2.1	1.4
	Maximum, mm	177.0	290.0	311.0	405.0	420.0
	Mean, mm	74.5	95.7	112.7	120.8	134.5
	Median, mm	70.5	84.5	103.8	107.0	112.0
	Minimum, mm	21.0	14.0	21.0	12.0	41.1
	Skewness	0.9	1.1	1.0	1.3	1.3
	Standard Deviation	33.5	54.6	58.6	78.5	90.2
Pipalu (177)	Coefficient of variation	0.5	0.6	0.5	0.6	0.6
	Kurtosis	1.7	1.0	0.6	0.3	-0.1
	Maximum, mm	272.0	314.0	345.0	365.0	374.0
	Mean, mm	100.0	115.6	140.1	132.0	141.7
	Median, mm	84.0	98.5	118.4	105.0	121.1
	Minimum, mm	38.0	24.0	61.0	19.0	22.0
	Skewness	1.5	1.3	1.2	1.0	0.9
	Standard Deviation	52.6	67.2	68.2	80.5	90.2
Pisangan (345)	Coefficient of variation	0.5	0.6	0.5	0.7	0.7
	Kurtosis	0.8	3.9	2.6	6.2	3.9
	Maximum, mm	176.0	313.0	325.0	460.0	472.0
	Mean, mm	68.5	93.6	108.7	117.7	142.7
	Median, mm	63.9	90.0	104.7	109.5	117.5
	Minimum, mm	25.0	13.0	31.0	25.0	59.0
	Skewness	0.9	1.4	1.2	2.2	2.0
	Standard Deviation	31.8	51.7	54.7	83.9	97.4
Pushkar (346)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	0.4	0.2	-0.3	1.0	0.0
	Maximum, mm	210.0	270.0	285.0	372.0	378.0
	Mean, mm	85.3	112.3	124.2	135.3	156.5
	Median, mm	80.8	104.2	118.0	135.0	138.7
	Minimum, mm	14.0	17.7	18.0	32.0	39.0
	Skewness	0.9	0.8	0.7	1.1	0.9
	Standard Deviation	44.4	58.6	67.0	78.0	91.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Rahuwas * (188)	Coefficient of variation	0.8	0.8	0.8	0.8	0.8
	Kurtosis	21.9	22.1	21.9	15.2	12.0
	Maximum, mm	426.0	583.1	692.4	740.9	764.5
	Mean, mm	79.7	105.0	128.0	145.4	165.8
	Median, mm	62.3	86.8	103.0	114.6	139.8
	Minimum, mm	35.0	37.9	42.2	28.6	46.2
	Skewness	4.3	4.3	4.3	3.5	3.2
	Standard Deviation	59.9	82.6	97.7	117.1	129.2
Sambhar (428)	Coefficient of variation	0.6	0.7	0.6	0.7	0.7
	Kurtosis	1.3	1.6	1.9	1.3	1.5
	Maximum, mm	237.5	334.8	381.0	392.9	447.0
	Mean, mm	87.0	111.9	127.9	128.8	139.4
	Median, mm	74.7	87.8	103.4	96.7	111.5
	Minimum, mm	28.5	31.7	33.4	13.2	13.7
	Skewness	1.3	1.5	1.5	1.4	1.4
	Standard Deviation	47.9	72.8	79.9	90.9	101.6
Sanganer (190)	Coefficient of variation	0.6	0.7	0.7	0.8	0.9
	Kurtosis	12.6	14.8	20.9	22.2	18.0
	Maximum, mm	388.0	550.5	685.3	803.3	820.3
	Mean, mm	91.1	117.4	134.8	137.0	132.6
	Median, mm	76.1	102.6	118.6	116.8	106.0
	Minimum, mm	35.0	11.0	40.6	28.0	18.0
	Skewness	3.1	3.2	4.0	4.2	3.7
	Standard Deviation	56.0	78.3	92.1	111.0	121.9
Sarwar (160)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	2.7	2.6	2.2	0.6	-0.8
	Maximum, mm	203.8	243.0	264.0	229.0	212.0
	Mean, mm	78.9	98.9	111.7	101.7	105.6
	Median, mm	70.0	88.1	105.0	96.0	98.0
	Minimum, mm	33.7	35.6	55.0	43.0	46.0
	Skewness	1.6	1.6	1.4	0.8	0.5
	Standard Deviation	33.6	41.3	42.9	39.7	45.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sikrai (226)	Coefficient of variation	0.6	0.7	0.6	0.7	0.6
	Kurtosis	4.0	10.1	10.0	6.8	7.6
	Maximum, mm	289.2	527.4	589.4	604.2	605.0
	Mean, mm	92.7	122.8	142.6	141.2	157.2
	Median, mm	79.5	106.5	121.6	129.0	142.0
	Minimum, mm	14.0	17.0	22.0	6.6	24.0
	Skewness	1.9	2.7	2.7	2.1	2.4
	Standard Deviation	52.7	80.4	89.1	101.1	100.1
Sri Nagar (161)	Coefficient of variation	0.6	0.7	0.7	0.7	0.7
	Kurtosis	1.0	2.8	6.5	0.4	0.6
	Maximum, mm	260.0	350.0	500.0	309.0	312.0
	Mean, mm	84.8	97.7	119.0	102.9	111.0
	Median, mm	71.5	79.0	97.5	89.0	107.0
	Minimum, mm	12.0	16.0	27.0	9.0	22.0
	Skewness	1.2	1.5	2.1	1.0	1.0
	Standard Deviation	53.9	65.4	82.5	73.8	76.7
Toda Rai Singh (131)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	0.7	-0.1	-0.6	-0.4	-0.1
	Maximum, mm	215.0	271.5	292.0	332.0	347.0
	Mean, mm	91.6	119.2	139.8	143.8	146.8
	Median, mm	82.5	104.5	123.5	123.0	123.6
	Minimum, mm	30.0	9.0	33.0	51.1	59.0
	Skewness	1.1	0.7	0.6	0.8	0.9
	Standard Deviation	43.7	60.2	64.0	70.5	75.3
Tonk (132)	Coefficient of variation	1.1	0.4	0.4	0.5	0.5
	Kurtosis	-0.4	-0.4	-0.2	-0.7	-0.5
	Maximum, mm	238.0	277.4	293.8	316.8	333.2
	Mean, mm	63.8	144.2	157.7	154.8	155.9
	Median, mm	67.2	123.8	139.3	144.0	145.0
	Minimum, mm	0.0	29.2	8.2	50.8	51.3
	Skewness	0.7	0.4	-0.1	0.5	0.6
	Standard Deviation	70.2	59.2	67.8	71.7	76.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Tonk * (133)	Coefficient of variation	0.4	0.5	0.4	0.5	0.6
	Kurtosis	1.5	1.7	6.1	4.6	4.3
	Maximum, mm	230.0	302.6	433.6	473.7	499.8
	Mean, mm	93.7	122.0	143.2	145.3	148.5
	Median, mm	85.9	110.3	128.6	136.6	127.6
	Minimum, mm	31.0	37.2	49.0	27.0	33.3
	Skewness	1.3	1.2	2.0	1.7	1.7
	Standard Deviation	41.5	55.7	64.4	77.1	85.9
Tordi Sagar* (164)	Coefficient of variation	0.9	0.6	0.5	0.6	0.5
	Kurtosis	0.2	1.9	1.3	0.1	0.5
	Maximum, mm	214.0	308.0	324.0	338.0	355.0
	Mean, mm	61.7	101.3	119.2	130.6	160.4
	Median, mm	53.2	86.5	105.1	117.8	157.7
	Minimum, mm	0.0	32.0	50.0	43.0	60.0
	Skewness	0.8	1.4	1.2	0.8	0.9
	Standard Deviation	53.7	62.9	64.4	77.5	74.9
ACZ IIIb						
Ajan * (206)	Coefficient of variation	0.7	0.6	0.6	0.6	0.6
	Kurtosis	8.3	4.1	2.8	2.6	1.9
	Maximum, mm	360.0	381.0	401.0	470.0	478.0
	Mean, mm	87.3	112.3	132.3	141.4	161.3
	Median, mm	70.0	95.8	111.2	124.0	151.0
	Minimum, mm	34.0	22.0	34.0	13.0	16.0
	Skewness	2.7	1.9	1.6	1.5	1.3
	Standard Deviation	58.8	67.6	73.9	88.5	94.4
Alwar (243)	Coefficient of variation	0.5	0.6	0.6	0.7	0.5
	Kurtosis	4.7	12.4	10.9	8.9	5.8
	Maximum, mm	282.5	543.0	567.5	568.5	432.0
	Mean, mm	92.6	126.1	142.5	136.3	141.0
	Median, mm	87.5	115.3	124.9	120.8	127.8
	Minimum, mm	25.2	39.0	52.2	24.0	40.0
	Skewness	1.7	3.0	2.9	2.6	2.0
	Standard Deviation	45.1	79.5	83.6	91.8	69.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Angai * (199)	Coefficient of variation	0.5	0.5	0.4	0.5	0.5
	Kurtosis	1.4	2.6	2.6	1.5	1.0
	Maximum, mm	189.0	273.0	327.0	351.0	367.5
	Mean, mm	76.2	101.0	120.4	129.3	138.7
	Median, mm	71.4	97.0	114.0	121.7	128.2
	Minimum, mm	27.5	38.0	38.0	25.0	25.2
	Skewness	1.2	1.4	1.3	0.9	0.8
	Standard Deviation	36.3	45.5	53.7	63.4	69.1
Bamanwas (192)	Coefficient of variation	0.7	0.8	0.9	1.0	0.9
	Kurtosis	25.7	21.5	27.6	27.0	21.9
	Maximum, mm	505.0	760.0	1030.0	1238.0	1251.0
	Mean, mm	92.0	129.2	155.0	172.5	194.7
	Median, mm	76.0	108.3	121.3	129.5	158.0
	Minimum, mm	40.0	16.0	62.0	44.0	30.0
	Skewness	4.7	4.2	4.9	4.8	4.3
	Standard Deviation	66.0	105.5	137.5	171.5	182.9
Bansur (252)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	-1.0	-0.9	-0.6	0.5	0.6
	Maximum, mm	183.2	261.0	301.0	320.0	374.4
	Mean, mm	96.1	124.9	142.8	133.3	149.3
	Median, mm	90.0	128.3	143.5	113.0	131.0
	Minimum, mm	18.0	18.0	18.0	43.8	52.0
	Skewness	0.3	0.3	0.4	1.0	1.1
	Standard Deviation	40.8	58.5	64.2	67.2	77.9
Baretha * (230)	Coefficient of variation	0.6	0.5	0.5	0.6	0.6
	Kurtosis	1.6	0.9	0.7	2.0	1.6
	Maximum, mm	262.0	321.0	336.0	407.0	421.0
	Mean, mm	88.4	115.2	133.0	130.1	140.1
	Median, mm	70.0	90.5	104.8	101.8	113.4
	Minimum, mm	33.0	45.0	53.0	35.0	42.9
	Skewness	1.4	1.2	1.2	1.5	1.5
	Standard Deviation	50.2	62.3	70.4	82.9	89.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bari (200)	Coefficient of variation	0.4	0.4	0.4	0.6	0.6
	Kurtosis	3.1	5.9	7.6	7.2	5.1
	Maximum, mm	248.0	391.0	462.5	518.5	538.0
	Mean, mm	95.2	132.2	150.4	137.3	143.1
	Median, mm	87.2	125.6	135.8	127.8	120.6
	Minimum, mm	40.0	42.0	62.0	29.7	30.5
	Skewness	1.6	1.8	2.2	2.0	1.8
	Standard Deviation	40.1	57.0	65.2	80.8	91.0
Baseri (233)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	3.4	2.4	2.5	1.4	1.0
	Maximum, mm	188.0	256.0	290.0	307.0	314.0
	Mean, mm	71.0	95.8	108.9	110.6	117.3
	Median, mm	64.5	86.0	96.0	94.5	99.7
	Minimum, mm	27.0	26.0	51.0	14.0	27.0
	Skewness	1.6	1.5	1.5	1.2	1.1
	Standard Deviation	33.0	47.2	49.5	58.8	64.1
Bayana (231)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.6	1.3	0.2	-0.1	0.9
	Maximum, mm	235.0	314.4	318.2	307.0	345.0
	Mean, mm	91.5	121.3	137.6	139.5	135.7
	Median, mm	77.5	112.4	123.8	132.0	135.0
	Minimum, mm	31.3	41.6	46.8	36.5	38.5
	Skewness	1.3	1.2	0.9	0.7	1.1
	Standard Deviation	47.6	59.7	65.4	68.6	74.4
Behror (253)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	2.4	2.7	1.9	0.4	0.4
	Maximum, mm	267.0	379.0	394.6	403.8	412.4
	Mean, mm	90.6	113.2	130.9	143.6	156.1
	Median, mm	76.5	93.6	103.5	113.2	140.0
	Minimum, mm	38.0	34.0	43.0	36.0	33.6
	Skewness	1.5	1.5	1.4	1.1	1.0
	Standard Deviation	46.9	70.1	74.0	88.1	92.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bharatpur (208)	Coefficient of variation	0.6	0.5	0.4	0.6	0.6
	Kurtosis	9.6	4.8	3.7	3.0	5.3
	Maximum, mm	336.0	346.0	359.0	408.0	451.0
	Mean, mm	92.2	113.8	133.0	129.1	132.6
	Median, mm	82.2	99.4	117.8	110.2	117.0
	Minimum, mm	41.0	41.0	65.9	26.0	48.5
	Skewness	2.8	1.9	1.7	1.4	2.0
	Standard Deviation	50.8	55.1	55.7	72.9	79.6
Bonli (193)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	2.5	5.1	6.8	3.9	3.1
	Maximum, mm	264.0	418.0	549.0	580.0	617.0
	Mean, mm	88.4	119.0	142.9	163.2	192.7
	Median, mm	76.6	98.8	115.9	134.0	156.5
	Minimum, mm	16.0	17.0	23.0	25.0	66.0
	Skewness	1.5	1.9	2.2	1.7	1.7
	Standard Deviation	46.9	68.3	87.7	102.7	115.3
Deeg (209)	Coefficient of variation	0.5	0.7	0.7	0.7	0.5
	Kurtosis	8.9	13.5	10.7	10.7	-0.7
	Maximum, mm	301.0	526.0	546.0	548.0	248.8
	Mean, mm	86.9	111.7	127.5	127.7	115.3
	Median, mm	78.7	94.0	106.0	109.8	102.5
	Minimum, mm	24.0	14.0	24.0	42.0	46.2
	Skewness	2.6	3.2	2.9	2.7	0.6
	Standard Deviation	47.4	78.2	83.1	83.6	56.3
Dholpur (8)	Coefficient of variation	0.3	0.4	0.4	0.5	0.5
	Kurtosis	-0.9	0.4	1.9	1.3	0.8
	Maximum, mm	140.1	247.2	339.5	349.5	352.2
	Mean, mm	84.1	112.3	134.8	138.0	146.4
	Median, mm	82.5	106.5	127.0	120.0	125.2
	Minimum, mm	35.1	28.2	35.1	36.8	47.0
	Skewness	0.2	0.5	1.0	1.1	1.1
	Standard Deviation	28.6	44.7	56.4	65.0	69.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dholpur (a) (673)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	-0.6	0.1	1.6	2.1	1.5
	Maximum, mm	158.0	247.1	339.4	358.5	361.2
	Mean, mm	86.3	115.2	135.5	130.6	132.6
	Median, mm	83.0	109.8	131.0	113.4	118.6
	Minimum, mm	32.0	35.4	38.0	36.2	36.1
	Skewness	0.2	0.6	0.9	1.3	1.0
	Standard Deviation	30.7	48.0	58.8	64.6	68.6
Gangapur City (194)	Coefficient of variation	0.5	0.6	0.6	0.7	0.7
	Kurtosis	3.3	3.8	3.1	1.9	1.7
	Maximum, mm	280.0	464.0	493.0	511.0	558.0
	Mean, mm	95.6	135.3	155.8	165.2	183.7
	Median, mm	84.0	114.0	131.0	135.0	145.2
	Minimum, mm	33.0	48.0	50.0	23.0	39.0
	Skewness	1.7	1.9	1.8	1.5	1.5
	Standard Deviation	50.8	83.0	94.9	107.8	122.3
Govindgarh (244)	Coefficient of variation	0.5	0.6	0.5	0.6	0.5
	Kurtosis	6.7	6.3	6.8	6.1	6.6
	Maximum, mm, mm	285.0	427.0	463.0	480.0	490.0
	Mean, mm, mm	90.0	118.7	134.9	140.3	151.9
	Median, mm, mm	85.0	105.5	112.4	112.0	126.5
	Minimum, mm, mm	38.0	45.0	58.0	67.0	58.0
	Skewness	2.0	2.2	2.2	2.2	2.2
	Standard Deviation	41.8	67.7	70.5	78.4	80.5
Halena * (210)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	7.9	1.5	1.6	0.5	-0.3
	Maximum, mm	265.0	289.0	300.0	303.0	297.2
	Mean, mm	79.0	103.9	117.6	118.8	127.4
	Median, mm	73.5	93.0	105.0	108.8	119.2
	Minimum, mm	22.0	27.0	30.0	8.0	43.0
	Skewness	2.3	1.1	1.2	0.8	0.7
	Standard Deviation	40.7	54.0	53.8	64.0	66.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Hindaun (235)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	-0.2	1.3	2.8	1.4	1.2
	Maximum, mm	191.8	337.0	415.0	421.0	466.0
	Mean, mm	84.7	119.1	138.7	142.5	159.4
	Median, mm	73.9	106.0	122.6	131.0	140.0
	Minimum, mm	0.0	27.0	32.0	26.0	25.0
	Skewness	0.6	1.0	1.3	1.0	1.0
	Standard Deviation	45.4	62.6	70.4	80.3	90.5
Hingota * (211)	Coefficient of variation	0.5	0.4	0.4	0.4	0.4
	Kurtosis	8.1	1.6	0.7	0.3	-0.1
	Maximum, mm	251.0	272.0	286.0	295.6	302.6
	Mean, mm	81.1	109.9	128.4	134.0	144.6
	Median, mm	74.3	100.1	117.0	120.9	128.0
	Minimum, mm	37.0	44.0	44.0	41.0	54.5
	Skewness	2.3	1.3	1.0	0.9	0.9
	Standard Deviation	36.7	49.0	52.1	55.7	60.9
Juggar * (236)	Coefficient of variation	0.6	0.6	0.6	0.5	0.5
	Kurtosis	0.8	-0.1	-0.1	0.3	0.1
	Maximum, mm	225.0	276.0	308.0	330.0	350.0
	Mean, mm	81.0	108.6	126.4	145.6	151.9
	Median, mm	70.0	94.0	108.4	119.4	132.3
	Minimum, mm	7.9	8.0	8.0	14.6	5.2
	Skewness	1.1	0.8	0.6	0.8	0.8
	Standard Deviation	49.8	63.0	70.5	69.6	80.3
Kalisil * (197)	Coefficient of variation	0.6	0.7	0.6	0.7	0.7
	Kurtosis	3.8	4.3	3.7	2.4	3.1
	Maximum, mm	272.1	464.0	493.0	511.0	615.5
	Mean, mm	89.7	123.4	147.0	157.1	173.5
	Median, mm	80.0	108.0	121.0	127.1	142.9
	Minimum, mm	0.6	1.0	1.4	1.6	2.1
	Skewness	1.7	1.9	1.9	1.5	1.6
	Standard Deviation	50.4	84.0	91.6	107.5	122.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kaman (212)	Coefficient of variation	0.5	0.6	0.6	0.5	0.5
	Kurtosis	7.3	13.3	12.2	-0.4	-0.2
	Maximum, mm	309.6	536.6	571.6	294.0	318.0
	Mean, mm	97.8	127.3	146.0	130.5	137.0
	Median, mm	88.5	110.5	123.5	121.0	127.0
	Minimum, mm	49.0	36.1	59.0	25.0	37.0
	Skewness	2.3	3.0	2.9	0.5	0.7
	Standard Deviation	45.2	75.8	80.4	63.7	65.6
Karauli (238)	Coefficient of variation	0.5	0.6	0.6	0.5	0.5
	Kurtosis	13.5	13.8	9.3	1.2	3.0
	Maximum, mm	360.0	574.0	589.0	400.5	461.3
	Mean, mm	99.0	134.5	157.6	158.1	172.2
	Median, mm	90.2	118.3	137.9	150.4	164.4
	Minimum, mm	20.5	12.5	46.2	55.1	53.0
	Skewness	3.0	3.1	2.6	1.0	1.5
	Standard Deviation	48.3	81.4	87.8	72.8	83.5
Kathumbar (245)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	5.2	6.1	5.1	3.3	5.1
	Maximum, mm	260.0	356.0	376.0	386.0	391.0
	Mean, mm	83.7	110.6	125.7	123.8	126.0
	Median, mm	75.0	100.5	111.5	113.7	111.0
	Minimum, mm	36.0	46.0	47.0	11.0	29.0
	Skewness	2.0	2.2	2.0	1.4	1.9
	Standard Deviation	40.5	56.4	59.7	66.8	67.1
Kishangarh (158)	Coefficient of variation	0.5	0.6	0.5	0.7	0.8
	Kurtosis	0.2	0.2	-0.6	0.9	2.0
	Maximum, mm	196.0	270.0	274.3	397.6	411.6
	Mean, mm	79.7	104.7	122.0	124.5	117.4
	Median, mm	72.0	86.0	101.6	105.0	99.8
	Minimum, mm	24.0	23.0	33.0	22.1	25.3
	Skewness	0.8	1.0	0.7	1.1	1.4
	Standard Deviation	39.2	60.6	66.8	82.2	89.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kishangarh Bas (254)	Coefficient of variation	0.5	0.6	0.5	0.7	0.5
	Kurtosis	0.0	4.7	3.0	2.5	-0.5
	Maximum, mm	218.0	428.0	445.0	450.0	327.0
	Mean, mm	97.3	126.5	149.9	131.0	151.0
	Median, mm	89.5	115.1	148.5	108.0	144.2
	Minimum, mm	27.0	30.0	33.0	7.5	51.0
	Skewness	0.7	1.7	1.3	1.4	0.6
	Standard Deviation	45.0	71.5	75.4	85.8	69.7
Kotkasim (255)	Coefficient of variation	0.5	0.6	0.5	0.6	0.5
	Kurtosis	4.7	3.9	3.6	3.3	-0.3
	Maximum, mm	318.0	465.0	483.0	486.0	339.0
	Mean, mm	104.7	135.4	150.8	144.0	152.1
	Median, mm	97.0	129.5	143.0	130.2	134.0
	Minimum, mm	29.0	33.4	40.2	27.0	30.0
	Skewness	1.8	1.5	1.4	1.5	0.6
	Standard Deviation	56.3	79.7	80.9	88.3	75.2
Kumher (213)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	0.4	0.6	0.7	1.5	-0.2
	Maximum, mm	162.6	228.0	254.0	314.0	274.0
	Mean, mm	78.5	103.2	115.7	114.4	113.9
	Median, mm	76.0	98.5	105.0	107.9	106.5
	Minimum, mm	26.2	35.0	43.0	30.0	36.5
	Skewness	0.7	0.8	0.9	1.1	0.6
	Standard Deviation	28.6	40.9	44.4	57.6	56.0
Mahuwa (228)	Coefficient of variation	0.6	0.6	0.6	0.6	0.6
	Kurtosis	4.2	2.2	2.9	2.7	0.6
	Maximum, mm	304.7	359.0	429.0	430.0	408.0
	Mean, mm	90.5	121.4	139.2	145.2	161.2
	Median, mm	76.0	110.0	123.4	120.0	128.0
	Minimum, mm	5.6	42.0	5.6	36.8	44.0
	Skewness	1.9	1.5	1.6	1.6	1.1
	Standard Deviation	57.0	70.9	79.0	83.0	89.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Malakhera (247)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	3.8	3.0	2.2	1.0	0.8
	Maximum, mm	252.0	314.0	341.0	331.0	328.0
	Mean, mm	86.2	113.0	128.2	130.0	140.5
	Median, mm	73.5	105.0	115.0	121.8	135.0
	Minimum, mm	25.0	9.0	25.0	17.0	42.0
	Skewness	1.8	1.5	1.4	1.0	1.0
	Standard Deviation	45.7	56.8	63.2	68.2	65.9
Mandawar (256)	Coefficient of variation	0.5	0.6	0.5	0.6	0.6
	Kurtosis	1.4	3.0	5.4	0.6	0.4
	Maximum, mm	266.0	418.0	494.0	351.0	398.0
	Mean, mm	95.5	125.6	144.9	137.9	152.8
	Median, mm	85.3	106.1	131.2	124.8	140.0
	Minimum, mm	37.0	21.0	46.0	24.9	25.3
	Skewness	1.2	1.4	1.9	1.0	1.0
	Standard Deviation	48.1	72.5	78.5	80.4	90.8
Morel Dam * (406)	Coefficient of variation	0.6	0.6	0.7	0.7	0.7
	Kurtosis	9.5	14.8	17.3	15.0	13.6
	Maximum, mm	324.5	507.0	631.2	697.6	709.5
	Mean, mm	86.3	121.2	135.8	153.2	163.7
	Median, mm	74.7	105.5	122.1	138.3	151.8
	Minimum, mm	31.0	49.5	31.0	36.0	38.0
	Skewness	2.7	3.5	3.8	3.6	3.5
	Standard Deviation	51.7	78.5	94.2	113.2	117.9
Moran Sagar * (196)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	10.4	11.8	16.9	10.1	7.0
	Maximum, mm	270.0	424.0	531.0	543.0	550.0
	Mean, mm	75.2	106.1	123.4	137.0	155.6
	Median, mm	63.8	93.5	111.8	110.0	125.7
	Minimum, mm	36.0	41.0	47.0	38.0	65.0
	Skewness	2.9	2.9	3.5	2.8	2.4
	Standard Deviation	39.4	60.8	71.9	84.8	93.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Nadbai (214)	Coefficient of variation	0.5	0.5	0.4	0.5	0.5
	Kurtosis	4.8	0.5	0.2	0.0	-0.6
	Maximum, mm	320.8	290.0	320.8	352.0	317.0
	Mean, mm	101.7	122.4	146.9	144.8	152.8
	Median, mm	89.0	112.4	137.6	132.6	143.0
	Minimum, mm	28.0	30.4	39.0	43.0	49.6
	Skewness	1.8	0.8	0.7	0.8	0.5
	Standard Deviation	50.9	56.7	65.7	73.9	69.7
Nadoti (241)	Coefficient of variation	0.6	0.7	0.7	0.7	0.7
	Kurtosis	9.9	17.1	16.9	13.9	9.5
	Maximum, mm	354.0	604.0	647.0	654.0	669.0
	Mean, mm	90.5	121.1	137.0	144.0	158.8
	Median, mm	76.6	105.4	118.4	116.0	130.0
	Minimum, mm	32.7	31.0	45.0	46.0	46.0
	Skewness	2.6	3.6	3.6	3.3	2.8
	Standard Deviation	52.1	84.8	90.4	97.0	110.1
Nagar (215)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	2.7	4.2	3.4	4.0	1.5
	Maximum, mm	235.0	307.0	337.0	348.0	352.0
	Mean, mm	83.2	102.7	118.4	112.8	127.0
	Median, mm	75.0	98.7	115.4	109.7	117.0
	Minimum, mm	21.0	38.0	44.0	33.0	27.0
	Skewness	1.5	1.6	1.4	1.5	1.0
	Standard Deviation	40.1	47.7	53.4	56.5	65.9
Neemrana (257)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	0.0	0.2	0.1	0.7	-0.1
	Maximum, mm	225.0	306.0	338.0	345.0	359.0
	Mean, mm	98.3	126.1	146.4	135.9	144.7
	Median, mm	93.0	110.5	131.5	122.5	142.7
	Minimum, mm	14.0	21.0	30.0	34.0	28.0
	Skewness	0.6	0.8	0.8	0.9	0.6
	Standard Deviation	45.2	67.3	70.8	66.2	81.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Pahari (541)	Coefficient of variation	0.5	0.6	0.6	0.4	0.4
	Kurtosis	10.9	12.5	13.4	-0.3	-0.2
	Maximum, mm	255.0	380.0	435.0	189.9	222.4
	Mean, mm	69.8	91.3	106.1	97.7	107.2
	Median, mm	64.8	76.6	94.0	92.6	95.2
	Minimum, mm	21.0	25.8	27.7	37.9	43.5
	Skewness	2.6	3.0	3.1	0.6	0.7
	Standard Deviation	35.8	55.2	61.9	38.1	46.0
Rajgarh (249)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.0	2.7	5.7	6.1	5.1
	Maximum, mm	185.4	309.0	396.0	400.0	404.0
	Mean, mm	80.3	106.0	121.8	119.7	133.1
	Median, mm	71.5	93.5	108.0	100.0	110.0
	Minimum, mm	24.0	24.0	28.0	35.0	44.0
	Skewness	1.2	1.3	2.0	2.2	2.1
	Standard Deviation	36.7	51.4	62.9	65.4	68.2
Ramgarh (248)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	0.7	5.8	3.7	3.1	3.8
	Maximum, mm	225.0	416.0	432.0	443.0	452.0
	Mean, mm	89.2	119.9	134.9	132.9	139.2
	Median, mm	77.5	105.0	114.6	123.0	127.2
	Minimum, mm	22.0	31.0	31.0	14.0	27.0
	Skewness	0.9	1.9	1.6	1.4	1.6
	Standard Deviation	42.2	65.7	73.2	80.8	81.4
Rupwas (234)	Coefficient of variation	0.7	0.5	0.5	0.6	0.6
	Kurtosis	19.2	0.6	10.1	-0.4	-0.8
	Maximum, mm	501.0	256.0	501.0	290.3	301.7
	Mean, mm	96.4	112.6	136.8	123.7	133.2
	Median, mm	80.5	101.6	119.8	119.5	125.5
	Minimum, mm	21.0	33.0	42.0	7.5	22.7
	Skewness	3.9	1.0	2.6	0.5	0.4
	Standard Deviation	69.2	51.2	71.7	69.5	77.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sapotra (198)	Coefficient of variation	0.7	0.8	0.7	0.8	0.8
	Kurtosis	3.1	4.1	3.0	2.1	2.6
	Maximum, mm	272.0	464.0	493.0	511.0	616.0
	Mean, mm	84.4	114.7	139.2	145.6	157.2
	Median, mm	78.0	94.0	115.0	118.0	126.7
	Minimum, mm	0.6	0.9	1.2	0.5	0.3
	Skewness	1.4	1.9	1.6	1.5	1.6
	Standard Deviation	55.2	91.4	101.8	117.1	133.4
Sepau (202)	Coefficient of variation	0.4	0.4	0.4	0.5	0.6
	Kurtosis	0.9	2.4	1.3	0.8	0.7
	Maximum, mm	202.0	294.0	302.8	326.3	405.7
	Mean, mm	89.7	115.1	133.1	136.8	149.2
	Median, mm	77.8	108.1	121.0	119.0	122.0
	Minimum, mm	44.0	51.0	61.0	40.6	46.0
	Skewness	1.3	1.5	1.2	1.1	1.1
	Standard Deviation	39.2	48.6	50.3	67.6	87.7
Sewar * (217)	Coefficient of variation	0.6	0.5	0.4	0.5	0.4
	Kurtosis	3.1	1.4	0.3	1.6	-0.6
	Maximum, mm	234.9	245.8	255.0	325.0	228.0
	Mean, mm	83.5	108.3	123.7	122.4	121.0
	Median, mm	70.3	104.0	110.5	116.0	113.4
	Minimum, mm	33.0	43.0	48.0	13.0	16.0
	Skewness	1.8	1.3	1.0	0.9	0.2
	Standard Deviation	46.9	49.5	52.2	59.8	53.3
Siliserh * (250)	Coefficient of variation	0.4	0.5	0.5	0.6	0.5
	Kurtosis	0.8	-0.4	0.9	0.9	0.0
	Maximum, mm	180.0	211.6	304.6	318.6	327.6
	Mean, mm	79.4	104.0	121.1	118.3	144.3
	Median, mm	75.5	95.9	111.1	102.2	131.8
	Minimum, mm	29.8	41.4	44.1	17.9	21.5
	Skewness	0.7	0.8	1.1	1.2	0.8
	Standard Deviation	32.1	47.9	56.8	65.9	71.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sirmathura (203)	Coefficient of variation	0.5	0.7	0.6	0.7	0.7
	Kurtosis	7.6	14.0	13.0	9.9	5.9
	Maximum, mm	318.0	543.0	570.0	577.0	591.0
	Mean, mm	93.0	118.3	139.0	130.6	155.4
	Median, mm	80.5	98.5	125.0	104.0	116.6
	Minimum, mm	26.5	21.0	26.5	33.0	57.0
	Skewness	2.5	3.3	3.1	2.8	2.3
	Standard Deviation	50.6	78.6	80.8	93.5	110.6
Sodawas * (258)	Coefficient of variation	0.5	0.6	0.6	0.6	0.7
	Kurtosis	1.7	2.0	1.7	2.7	2.6
	Maximum, mm	207.2	334.3	365.3	402.4	420.1
	Mean, mm	78.1	106.1	119.9	122.4	122.0
	Median, mm	71.9	88.0	98.0	105.9	108.0
	Minimum, mm	26.0	11.0	30.8	20.0	20.4
	Skewness	1.2	1.5	1.4	1.4	1.4
	Standard Deviation	37.9	66.6	71.8	74.0	80.6
Talabshahi * (204)	Coefficient of variation	0.6	0.7	0.7	0.8	0.9
	Kurtosis	8.0	4.6	5.3	9.4	11.0
	Maximum, mm	356.8	416.0	530.0	694.0	824.8
	Mean, mm	87.8	115.7	137.6	148.6	158.5
	Median, mm	73.5	92.7	117.0	121.1	122.0
	Minimum, mm	10.0	20.1	10.0	36.0	30.6
	Skewness	2.3	2.0	2.2	2.6	2.9
	Standard Deviation	56.4	76.2	94.3	113.4	139.8
Tapukra (259)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	1.3	2.3	1.3	1.4	0.7
	Maximum, mm	225.0	309.0	346.0	386.0	387.0
	Mean, mm	87.2	113.1	134.6	138.1	150.3
	Median, mm	80.5	98.5	133.2	128.0	137.0
	Minimum, mm	33.0	49.0	57.0	22.0	45.1
	Skewness	1.2	1.5	1.1	1.1	1.1
	Standard Deviation	39.3	57.6	63.2	74.9	83.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Thanagazi (251)	Coefficient of variation	0.4	0.5	0.5	0.5	0.5
	Kurtosis	0.0	0.2	1.7	0.3	-0.4
	Maximum, mm	193.0	279.4	382.0	392.0	400.0
	Mean, mm	91.9	129.5	151.2	163.8	170.7
	Median, mm	88.0	123.0	141.5	146.0	165.0
	Minimum, mm	34.0	27.0	40.0	51.0	18.0
	Skewness	0.8	0.9	1.3	1.0	0.5
	Standard Deviation	37.6	60.0	71.6	80.3	93.5
Tijara (260)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	0.5	2.6	1.6	0.7	-0.2
	Maximum, mm	230.0	363.0	367.1	370.2	302.0
	Mean, mm	97.5	123.4	144.3	143.9	126.9
	Median, mm	96.0	113.2	131.5	127.0	117.0
	Minimum, mm	28.0	40.0	47.0	20.0	18.0
	Skewness	0.8	1.3	1.1	1.0	0.5
	Standard Deviation	44.3	61.5	68.3	78.6	66.5
Toda Bhim (229)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	3.8	3.7	4.1	3.1	4.1
	Maximum, mm	308.0	379.0	428.0	440.0	463.0
	Mean, mm	95.7	122.6	142.6	139.8	145.9
	Median, mm	81.0	101.0	128.0	126.0	132.0
	Minimum, mm	26.0	21.0	26.0	17.0	21.0
	Skewness	1.7	1.7	1.8	1.5	1.7
	Standard Deviation	51.4	67.1	74.5	83.8	85.7
Urmila Sagar * (9)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	-0.5	0.0	-0.3	-0.2	0.8
	Maximum, mm	190.4	251.4	263.6	270.8	342.3
	Mean, mm	86.5	110.5	127.3	124.7	138.0
	Median, mm	80.6	100.2	119.0	109.0	127.0
	Minimum, mm	32.0	26.0	32.0	25.0	34.0
	Skewness	0.6	0.8	0.6	0.9	1.0
	Standard Deviation	37.6	49.5	53.4	62.3	65.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Weir (219)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	2.1	0.1	-0.3	0.0	-0.4
	Maximum, mm	204.5	227.4	235.0	259.1	273.0
	Mean, mm	80.7	105.9	127.4	131.7	131.9
	Median, mm	75.5	96.0	118.0	122.0	123.0
	Minimum, mm	17.0	27.0	27.0	23.0	28.0
	Skewness	1.1	0.8	0.5	0.7	0.5
	Standard Deviation	32.7	42.9	48.0	55.4	61.2
ACZ Iva						
Abu Road (325)	Coefficient of variation	0.6	0.7	0.7	0.7	0.6
	Kurtosis	2.6	3.5	5.7	6.5	8.1
	Maximum, mm	303.0	504.0	646.0	717.0	745.0
	Mean, mm	100.3	138.0	163.2	178.4	182.9
	Median, mm	83.0	114.5	124.1	143.0	151.5
	Minimum, mm	19.1	21.6	24.1	29.2	42.8
	Skewness	1.6	1.7	2.1	2.2	2.5
	Standard Deviation	61.2	91.1	107.8	117.7	118.5
Agucha * (139)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	3.6	3.1	2.0	-0.5	0.2
	Maximum, mm	203.0	263.0	263.0	235.0	252.0
	Mean, mm	65.8	85.6	95.5	101.5	107.9
	Median, mm	59.1	72.0	85.0	92.3	100.4
	Minimum, mm	20.0	17.5	34.0	26.0	24.1
	Skewness	1.7	1.5	1.4	0.5	0.8
	Standard Deviation	35.4	46.9	48.2	53.0	56.0
Amet (73)	Coefficient of variation	0.5	0.5	0.4	0.6	0.5
	Kurtosis	0.2	0.8	0.3	-0.5	0.1
	Maximum, mm	204.0	246.0	262.0	265.0	269.0
	Mean, mm	83.4	100.1	116.6	110.4	115.7
	Median, mm	77.5	90.1	111.0	96.0	104.0
	Minimum, mm	25.0	35.5	37.0	14.0	24.0
	Skewness	0.8	1.1	0.9	0.6	0.7
	Standard Deviation	39.6	49.3	50.9	61.4	58.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Arwar Dam * (140)	Coefficient of variation	0.5	0.6	0.6	0.7	0.7
	Kurtosis	0.9	3.5	5.5	7.5	10.6
	Maximum, mm	210.0	340.0	430.0	447.0	454.0
	Mean, mm	84.1	107.9	124.5	116.8	110.4
	Median, mm	70.6	88.0	110.0	104.7	96.5
	Minimum, mm	30.0	36.0	40.0	36.6	26.4
	Skewness	1.3	1.9	2.1	2.6	2.8
	Standard Deviation	43.7	61.7	71.4	77.9	74.4
Asind (141)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	2.3	-0.1	-0.3	-0.4	1.4
	Maximum, mm	170.0	191.8	233.4	242.4	272.0
	Mean, mm	69.4	88.9	105.0	105.2	102.8
	Median, mm	64.9	77.3	90.4	92.8	91.5
	Minimum, mm	21.4	29.0	37.8	26.8	33.5
	Skewness	1.4	0.8	0.7	0.6	1.0
	Standard Deviation	30.1	38.4	45.0	51.1	51.3
Babalwara * (298)	Coefficient of variation	0.8	0.8	0.8	0.8	0.7
	Kurtosis	4.8	4.9	4.4	4.6	2.9
	Maximum, mm	370.0	515.4	605.4	625.4	571.3
	Mean, mm	92.7	126.1	147.2	154.8	161.6
	Median, mm	63.1	90.9	103.6	108.2	122.1
	Minimum, mm	20.0	24.0	24.0	44.0	47.6
	Skewness	2.2	2.2	2.1	2.2	1.8
	Standard Deviation	75.2	103.7	120.3	122.0	114.4
Badgaon * (84)	Coefficient of variation	0.5	0.5	0.5	0.5	0.7
	Kurtosis	3.1	5.7	3.9	2.2	1.1
	Maximum, mm	225.0	335.0	360.0	373.0	414.0
	Mean, mm	80.9	109.9	125.2	126.0	132.6
	Median, mm	73.0	94.5	110.0	99.5	100.6
	Minimum, mm	32.0	48.0	56.0	43.0	32.0
	Skewness	1.4	1.9	1.7	1.5	1.3
	Standard Deviation	37.3	51.1	57.9	68.5	91.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Badi Sadri (86)	Coefficient of variation	0.5	0.4	0.4	0.5	0.5
	Kurtosis	10.0	4.9	2.7	1.4	0.6
	Maximum, mm	355.6	400.3	413.5	434.8	455.4
	Mean, mm	103.8	137.4	156.4	164.2	167.1
	Median, mm	90.5	122.4	141.0	146.5	158.0
	Minimum, mm	37.0	56.9	63.8	42.0	31.3
	Skewness	2.5	1.8	1.4	1.1	0.8
	Standard Deviation	49.9	60.2	66.2	75.9	87.8
Badnore (142)	Coefficient of variation	0.4	0.5	0.4	0.5	0.4
	Kurtosis	0.3	-0.2	-0.1	-0.4	0.3
	Maximum, mm	138.0	170.0	191.0	201.0	210.0
	Mean, mm	58.9	75.2	90.0	91.3	97.1
	Median, mm	56.8	63.0	80.6	82.1	85.9
	Minimum, mm	17.0	20.0	20.0	19.0	26.3
	Skewness	0.7	0.8	0.7	0.5	0.7
	Standard Deviation	26.3	36.8	39.3	45.5	41.3
Bagolia * (99)	Coefficient of variation	0.6	0.6	0.5	0.6	0.5
	Kurtosis	5.4	6.5	4.6	6.2	10.4
	Maximum, mm	228.0	330.0	344.0	347.0	361.0
	Mean, mm	70.7	94.6	108.8	100.6	107.5
	Median, mm	68.0	81.3	96.4	89.9	91.6
	Minimum, mm	27.0	31.2	31.7	10.8	37.9
	Skewness	2.0	2.2	1.8	1.9	2.8
	Standard Deviation	39.3	52.3	55.3	55.6	54.8
Banera (143)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	1.3	0.2	0.7	1.0	0.9
	Maximum, mm	187.0	223.0	254.0	298.1	353.9
	Mean, mm	85.7	111.0	129.2	122.2	134.9
	Median, mm	81.8	106.0	123.0	119.5	134.6
	Minimum, mm	40.6	43.0	58.0	27.0	12.0
	Skewness	1.2	0.6	0.9	0.8	0.7
	Standard Deviation	33.2	40.1	46.9	56.6	68.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Begun (5)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	2.5	0.8	0.2	2.4	2.1
	Maximum, mm	300.0	358.0	390.0	575.0	607.0
	Mean, mm	111.7	149.8	172.4	180.3	196.1
	Median, mm	100.0	129.0	155.4	163.1	187.4
	Minimum, mm	45.0	52.0	58.0	11.7	35.6
	Skewness	1.5	1.1	0.9	1.3	1.2
	Standard Deviation	55.7	70.4	79.3	104.4	111.1
Bhadesar (85)	Coefficient of variation	0.3	0.3	0.3	0.5	0.5
	Kurtosis	0.8	0.3	-0.3	-0.5	-1.2
	Maximum, mm	169.2	241.8	273.5	321.0	300.5
	Mean, mm	93.8	124.4	147.3	149.7	167.0
	Median, mm	88.7	113.2	137.3	125.0	150.5
	Minimum, mm	42.0	50.0	58.0	42.0	48.0
	Skewness	1.1	0.9	0.6	0.7	0.4
	Standard Deviation	29.1	42.8	50.2	67.5	75.4
Bhainsrorgarh (4)	Coefficient of variation	0.6	0.5	0.5	0.6	0.5
	Kurtosis	2.0	1.6	0.6	0.9	0.2
	Maximum, mm	351.4	427.0	439.0	467.0	479.0
	Mean, mm	120.7	158.5	182.2	174.0	187.0
	Median, mm	106.0	137.4	161.4	162.4	151.9
	Minimum, mm	41.5	51.0	51.3	30.4	43.1
	Skewness	1.5	1.3	1.0	1.1	1.0
	Standard Deviation	66.6	81.8	87.0	98.6	101.1
Bharai * (651)	Coefficient of variation	0.5	0.4	0.4	0.4	0.4
	Kurtosis	2.9	0.3	-0.2	0.2	0.8
	Maximum, mm	188.0	185.0	189.3	233.6	257.0
	Mean, mm	69.8	87.2	103.1	106.8	117.1
	Median, mm	57.1	85.8	97.7	103.7	106.3
	Minimum, mm	26.4	30.5	50.0	26.0	31.0
	Skewness	1.6	0.9	0.8	0.7	1.0
	Standard Deviation	34.2	36.1	38.3	45.0	50.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bhilwara (111)	Coefficient of variation	0.5	0.5	0.4	0.5	0.5
	Kurtosis	4.1	1.2	0.8	0.2	1.0
	Maximum, mm	295.0	301.6	317.6	322.0	365.0
	Mean, mm	100.0	124.4	142.6	145.3	146.6
	Median, mm	90.5	108.0	133.1	131.4	132.2
	Minimum, mm	46.0	48.0	53.0	52.0	54.1
	Skewness	2.0	1.3	1.1	0.9	1.0
	Standard Deviation	52.3	57.8	59.6	66.5	69.5
Bhim (152)	Coefficient of variation	0.5	0.5	0.4	0.6	0.5
	Kurtosis	1.7	1.1	1.1	-0.7	-0.1
	Maximum, mm	207.0	259.0	285.0	253.0	254.0
	Mean, mm	86.0	107.1	121.7	109.8	117.0
	Median, mm	78.3	97.1	108.9	102.0	110.0
	Minimum, mm	24.0	27.0	28.0	8.0	25.0
	Skewness	1.4	1.2	1.0	0.4	0.7
	Standard Deviation	40.9	50.3	53.0	60.6	56.8
Bhopalsagar (87)	Coefficient of variation	0.4	0.5	0.5	0.5	0.5
	Kurtosis	4.8	0.2	1.4	0.6	-0.3
	Maximum, mm	224.0	247.0	316.0	322.0	327.0
	Mean, mm	77.0	103.2	120.7	132.7	135.3
	Median, mm	70.5	92.9	106.5	128.0	112.0
	Minimum, mm	34.7	40.0	55.0	51.0	18.0
	Skewness	1.7	1.0	1.2	0.9	0.8
	Standard Deviation	34.0	47.3	55.5	59.8	73.7
Bhula * (390)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	1.8	4.1	8.3	7.0	6.0
	Maximum, mm	227.7	407.9	562.7	595.4	625.9
	Mean, mm	82.5	120.2	138.8	161.6	174.0
	Median, mm	73.4	102.4	124.8	143.4	163.7
	Minimum, mm	8.4	24.2	8.4	24.2	33.2
	Skewness	1.2	1.7	2.3	2.1	2.0
	Standard Deviation	43.4	70.0	87.3	95.5	103.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bijolia (53)	Coefficient of variation	0.6	0.6	0.6	0.7	0.6
	Kurtosis	1.3	1.5	1.1	0.4	0.0
	Maximum, mm	385.0	500.0	502.0	503.0	480.0
	Mean, mm	123.2	162.3	178.7	176.1	180.5
	Median, mm	102.0	158.0	175.0	152.0	149.5
	Minimum, mm	22.6	23.2	34.5	35.0	23.8
	Skewness	1.2	1.2	1.1	1.0	0.9
	Standard Deviation	77.2	100.2	101.5	115.0	115.1
Chhoti Sadri (280)	Coefficient of variation	0.4	0.4	0.4	0.5	0.6
	Kurtosis	0.7	0.3	0.5	0.3	0.0
	Maximum, mm	220.0	322.2	360.8	389.8	434.0
	Mean, mm	107.3	145.2	168.9	174.0	173.2
	Median, mm	95.1	137.0	164.0	157.1	151.0
	Minimum, mm	39.1	47.7	68.3	41.2	28.2
	Skewness	1.0	0.7	0.8	0.7	0.7
	Standard Deviation	39.4	56.0	61.2	79.0	95.5
Chittaurgarh (89)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	1.2	0.4	0.1	-0.4	-0.8
	Maximum, mm	227.0	307.4	320.0	326.0	327.0
	Mean, mm	102.9	139.1	158.5	168.6	177.5
	Median, mm	93.7	128.3	136.8	150.3	160.6
	Minimum, mm	45.7	59.0	68.7	60.2	62.2
	Skewness	1.2	1.0	1.0	0.8	0.5
	Standard Deviation	40.9	58.0	62.4	67.4	73.9
Deo Garh (153)	Coefficient of variation	0.6	0.6	0.5	0.6	0.5
	Kurtosis	1.0	-0.7	-0.8	-0.3	-0.9
	Maximum, mm	240.0	247.0	279.0	312.0	301.0
	Mean, mm	86.2	114.5	131.7	124.5	139.6
	Median, mm	68.2	95.0	107.9	102.6	113.0
	Minimum, mm	20.0	25.6	31.2	23.0	36.0
	Skewness	1.3	0.7	0.7	0.8	0.5
	Standard Deviation	50.4	64.0	70.5	74.4	72.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Deoli (125)	Coefficient of variation	0.4	0.4	0.3	0.4	0.4
	Kurtosis	0.8	1.1	0.6	-0.3	-0.5
	Maximum, mm	182.0	260.0	264.0	270.3	282.3
	Mean, mm	84.2	112.3	125.7	125.8	135.5
	Median, mm	75.0	101.8	115.7	108.0	127.0
	Minimum, mm	39.8	49.6	50.6	39.2	40.4
	Skewness	1.1	1.2	0.9	0.7	0.5
	Standard Deviation	34.7	44.4	43.9	52.4	56.3
Dungla (90)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	-0.3	0.2	1.0	0.4	0.2
	Maximum, mm	181.0	274.8	357.0	381.0	393.0
	Mean, mm	95.4	134.9	157.3	160.1	161.0
	Median, mm	92.9	124.7	146.1	149.0	145.6
	Minimum, mm	27.0	45.0	60.0	36.7	48.0
	Skewness	0.5	0.8	1.1	0.9	1.0
	Standard Deviation	35.6	51.3	61.8	77.2	87.9
Gadola * (6)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	5.8	0.4	4.6	-0.1	-0.1
	Maximum, mm	266.0	275.0	401.0	314.2	354.5
	Mean, mm	99.3	135.9	155.5	159.7	170.7
	Median, mm	90.0	127.0	147.0	155.8	176.4
	Minimum, mm	36.0	33.0	43.0	59.0	50.0
	Skewness	2.0	0.8	1.7	0.7	0.5
	Standard Deviation	39.7	50.9	61.8	64.5	76.3
Gambhiri * (93)	Coefficient of variation	0.4	0.5	0.5	0.6	0.6
	Kurtosis	0.8	1.7	1.3	2.3	0.8
	Maximum, mm	256.3	423.8	461.0	547.1	551.1
	Mean, mm	114.3	155.7	178.3	181.4	194.3
	Median, mm	104.0	136.2	155.0	154.0	167.5
	Minimum, mm	48.4	38.0	68.4	55.0	38.2
	Skewness	1.1	1.2	1.2	1.4	0.9
	Standard Deviation	48.4	78.1	86.0	100.0	111.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Gangrar (92)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	1.9	6.9	5.8	2.8	0.9
	Maximum, mm	263.0	423.0	425.0	427.7	431.0
	Mean, mm	102.7	135.2	154.8	142.4	154.4
	Median, mm	92.0	118.0	148.4	131.0	138.9
	Minimum, mm	45.0	47.0	57.0	16.4	16.6
	Skewness	1.3	2.4	2.1	1.2	1.0
	Standard Deviation	45.2	68.1	68.2	72.8	84.0
Gogunda (76)	Coefficient of variation	0.6	0.6	0.5	0.6	0.6
	Kurtosis	1.3	2.3	1.7	3.2	3.1
	Maximum, mm	205.0	323.0	355.0	380.0	428.0
	Mean, mm	78.4	105.3	126.0	123.6	138.9
	Median, mm	67.0	92.0	109.0	106.5	121.0
	Minimum, mm	28.0	16.0	49.0	49.0	53.0
	Skewness	1.4	1.5	1.5	1.8	1.8
	Standard Deviation	43.2	60.0	66.9	68.9	82.9
Hurda (145)	Coefficient of variation	0.5	0.4	0.4	0.5	0.6
	Kurtosis	7.5	4.1	3.8	3.1	2.9
	Maximum, mm	278.0	305.0	337.0	364.0	389.0
	Mean, mm	84.8	107.0	122.2	116.8	121.1
	Median, mm	78.3	101.4	114.4	111.4	112.3
	Minimum, mm	29.0	31.0	33.0	20.0	18.5
	Skewness	2.1	1.4	1.4	1.3	1.4
	Standard Deviation	40.7	46.7	52.4	63.3	76.3
Jahazpur (117)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	0.9	2.4	1.7	0.8	0.7
	Maximum, mm	244.0	353.0	357.0	366.0	380.0
	Mean, mm	105.7	140.0	156.7	151.7	147.4
	Median, mm	97.5	127.8	142.0	148.0	148.0
	Minimum, mm	45.0	45.0	71.0	21.0	22.0
	Skewness	1.0	1.5	1.3	0.7	0.7
	Standard Deviation	46.1	64.9	65.9	74.6	75.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Jaisamand * (299)	Coefficient of variation	0.9	0.4	0.5	0.6	0.5
	Kurtosis	-0.4	-0.4	1.4	3.8	5.3
	Maximum, mm	206.8	247.8	358.0	428.4	463.4
	Mean, mm	64.0	124.0	148.7	134.8	152.1
	Median, mm	65.0	121.0	142.2	120.4	131.0
	Minimum, mm	0.0	47.8	51.6	31.3	55.6
	Skewness	0.5	0.6	1.1	1.5	2.0
	Standard Deviation	58.2	52.1	67.9	77.0	81.4
Jawaja (134)	Coefficient of variation	0.5	0.5	0.5	0.6	0.5
	Kurtosis	0.9	0.7	0.3	-0.6	0.3
	Maximum, mm	200.0	265.0	274.0	282.0	296.0
	Mean, mm	75.9	99.0	111.6	121.8	127.1
	Median, mm	69.5	85.0	93.4	102.5	111.0
	Minimum, mm	23.0	24.0	23.0	19.0	18.5
	Skewness	1.0	1.0	0.9	0.7	0.9
	Standard Deviation	37.1	54.3	57.6	70.8	69.0
Jhadol (321)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	4.0	3.6	2.9	3.8	5.4
	Maximum, mm	282.0	369.0	416.0	473.0	486.0
	Mean, mm	93.0	127.0	148.9	148.8	145.5
	Median, mm	82.0	107.0	129.0	129.5	129.0
	Minimum, mm	37.0	51.0	60.0	34.0	36.0
	Skewness	1.8	1.9	1.8	1.9	2.0
	Standard Deviation	47.2	67.1	78.7	86.9	82.5
Kadambari * (328)	Coefficient of variation	1.0	1.1	1.1	1.1	1.2
	Kurtosis	13.3	18.6	18.9	17.3	15.3
	Maximum, mm	620.0	940.0	1014.0	1052.0	1122.0
	Mean, mm	99.9	130.8	143.6	146.6	153.8
	Median, mm	75.0	102.0	113.0	114.3	106.0
	Minimum, mm	9.9	10.3	11.8	11.8	12.5
	Skewness	3.2	3.9	3.9	3.8	3.6
	Standard Deviation	99.2	143.5	152.8	166.4	189.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kapasan (94)	Coefficient of variation	0.4	0.4	0.4	0.5	0.4
	Kurtosis	0.3	-0.2	1.3	1.7	0.5
	Maximum, mm	167.0	218.6	291.0	296.0	301.0
	Mean, mm	81.7	107.2	125.6	118.4	135.6
	Median, mm	79.6	93.1	114.2	107.0	126.0
	Minimum, mm	41.0	46.0	50.0	38.6	39.1
	Skewness	0.9	0.8	1.2	1.3	0.9
	Standard Deviation	28.7	41.2	48.7	54.9	58.0
Khari Dam * (146)	Coefficient of variation	0.5	0.5	0.5	0.6	0.5
	Kurtosis	3.2	2.3	4.2	4.4	3.0
	Maximum, mm	203.4	267.7	323.6	354.8	356.1
	Mean, mm	73.5	94.3	107.3	99.3	125.5
	Median, mm	70.0	86.0	98.1	94.0	117.9
	Minimum, mm	30.0	21.0	37.0	19.0	32.0
	Skewness	1.6	1.2	1.6	1.8	1.6
	Standard Deviation	33.4	47.1	51.7	63.8	66.6
Kherwada (77)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	1.4	1.9	5.6	0.1	0.2
	Maximum, mm	182.0	289.0	384.0	281.0	304.0
	Mean, mm	81.6	113.8	131.5	128.5	139.5
	Median, mm	73.5	103.9	116.5	123.0	139.5
	Minimum, mm	32.0	51.0	56.0	41.0	22.0
	Skewness	1.2	1.3	1.9	0.8	0.6
	Standard Deviation	31.6	47.7	56.3	54.0	65.7
Kotra (315)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	1.4	1.3	2.9	2.5	4.8
	Maximum, mm	276.0	427.0	577.0	627.0	716.0
	Mean, mm	109.4	150.1	177.7	195.1	202.0
	Median, mm	95.0	129.0	152.0	156.0	162.0
	Minimum, mm	28.5	16.0	55.5	66.5	48.0
	Skewness	1.3	1.3	1.6	1.5	1.8
	Standard Deviation	53.9	87.3	102.4	112.6	120.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kotri (69)	Coefficient of variation	0.4	0.4	0.5	0.6	0.6
	Kurtosis	1.1	1.5	2.5	1.8	1.4
	Maximum, mm	241.0	334.0	419.0	433.0	452.0
	Mean, mm	100.9	133.2	152.5	140.8	158.8
	Median, mm	90.5	119.0	133.6	122.0	127.0
	Minimum, mm	43.2	62.0	62.0	14.0	32.7
	Skewness	1.1	1.3	1.5	1.2	1.3
	Standard Deviation	41.5	57.9	71.5	84.0	99.6
Kumbhalgarh (384)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	1.2	-0.1	0.5	1.1	1.7
	Maximum, mm	233.0	312.0	371.0	427.0	438.0
	Mean, mm	93.4	127.0	147.9	145.2	150.5
	Median, mm	76.0	112.5	128.0	113.5	115.8
	Minimum, mm	28.0	31.0	44.0	37.0	47.0
	Skewness	1.2	0.8	1.0	1.2	1.4
	Standard Deviation	45.2	65.6	74.1	88.7	93.4
Mandal (113)	Coefficient of variation	0.5	0.4	0.3	0.4	0.4
	Kurtosis	4.6	2.4	2.6	1.3	-0.7
	Maximum, mm	240.0	250.0	266.0	274.0	227.0
	Mean, mm	83.2	101.4	117.1	109.6	118.2
	Median, mm	76.0	101.6	113.2	106.5	122.0
	Minimum, mm	38.0	38.0	50.5	36.5	46.0
	Skewness	1.9	1.1	1.3	1.0	0.4
	Standard Deviation	37.4	39.4	39.0	48.5	48.8
Mandalgarh (68)	Coefficient of variation	0.5	0.5	0.4	0.5	0.5
	Kurtosis	0.5	0.3	0.8	0.8	1.5
	Maximum, mm	295.0	363.0	403.0	449.0	475.0
	Mean, mm	120.2	153.5	171.0	168.4	169.4
	Median, mm	108.0	147.0	153.1	143.5	146.0
	Minimum, mm	48.3	59.2	78.0	26.0	71.4
	Skewness	1.1	1.0	1.1	1.1	1.3
	Standard Deviation	57.6	72.0	73.4	86.0	88.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Maoli (102)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.9	1.1	0.0	0.4	0.1
	Maximum, mm	228.0	274.0	293.0	308.0	306.0
	Mean, mm	84.8	113.3	132.6	127.5	128.8
	Median, mm	71.4	102.5	121.4	113.2	118.0
	Minimum, mm	31.6	36.2	41.0	24.0	24.7
	Skewness	1.5	1.2	0.9	0.9	0.9
	Standard Deviation	42.5	55.1	60.4	64.6	68.5
Meja Dam * (114)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	2.4	-0.2	-0.5	-0.7	-0.4
	Maximum, mm	204.9	208.1	220.0	250.0	274.0
	Mean, mm	80.7	106.0	123.1	127.7	134.0
	Median, mm	71.1	99.0	112.0	121.5	143.0
	Minimum, mm	18.0	33.0	46.0	20.0	31.0
	Skewness	1.4	0.6	0.6	0.3	0.4
	Standard Deviation	35.0	41.4	44.4	57.0	59.5
Mount Abu (332)	Coefficient of variation	0.6	0.6	0.6	0.6	0.6
	Kurtosis	2.3	1.8	4.3	4.3	4.5
	Maximum, mm	700.0	937.0	1342.0	1437.0	1492.0
	Mean, mm	226.7	331.1	387.3	425.6	457.4
	Median, mm	201.3	308.3	337.5	389.9	423.0
	Minimum, mm	41.6	60.6	63.4	73.6	82.8
	Skewness	1.4	1.3	1.8	1.8	1.9
	Standard Deviation	127.6	191.6	238.5	255.8	265.2
Mount Abu (a) (331)	Coefficient of variation	0.6	0.6	0.7	0.6	0.6
	Kurtosis	0.8	2.0	4.2	3.9	5.3
	Maximum, mm	653.0	976.2	1344.0	1422.0	1469.0
	Mean, mm	232.3	333.6	392.2	438.1	469.5
	Median, mm	190.6	288.7	337.6	399.1	443.6
	Minimum, mm	47.0	63.7	82.6	28.0	147.2
	Skewness	1.1	1.4	1.9	1.8	2.1
	Standard Deviation	138.0	204.3	259.9	279.1	274.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Nahar Sagar * (147)	Coefficient of variation	0.4	0.5	0.5	0.6	0.6
	Kurtosis	0.3	1.7	2.1	3.0	2.9
	Maximum, mm	189.2	320.0	342.0	409.0	434.0
	Mean, mm	86.2	113.9	131.7	130.4	147.1
	Median, mm	80.0	99.0	120.0	118.0	137.0
	Minimum, mm	29.9	33.0	47.8	34.0	58.6
	Skewness	0.9	1.3	1.5	1.7	1.8
	Standard Deviation	36.8	58.6	64.9	80.2	86.1
Nathdwara (78)	Coefficient of variation	0.4	0.4	0.4	0.5	0.4
	Kurtosis	0.8	0.9	1.2	1.2	-0.4
	Maximum, mm	154.0	213.0	241.0	313.0	259.0
	Mean, mm	71.7	97.5	112.7	117.1	128.8
	Median, mm	70.0	90.0	101.0	110.0	121.0
	Minimum, mm	29.0	37.0	46.5	20.0	34.0
	Skewness	1.0	1.2	1.2	1.1	0.4
	Standard Deviation	26.8	40.7	44.6	62.7	55.4
Nimbahera (95)	Coefficient of variation	0.5	0.5	0.4	0.6	0.5
	Kurtosis	6.2	3.6	3.4	4.2	1.2
	Maximum, mm	362.0	461.0	502.0	597.0	461.6
	Mean, mm	117.0	158.4	181.2	178.8	174.0
	Median, mm	107.5	131.0	160.0	148.3	156.6
	Minimum, mm	47.6	70.0	72.0	65.8	46.0
	Skewness	2.0	1.7	1.7	1.8	1.0
	Standard Deviation	53.3	76.0	80.0	100.2	83.5
Orai * (96)	Coefficient of variation	0.4	0.4	0.3	0.5	0.5
	Kurtosis	-0.4	-0.3	0.0	-0.3	-0.7
	Maximum, mm	203.5	267.7	323.6	354.8	356.1
	Mean, mm	107.0	143.3	164.8	157.4	170.9
	Median, mm	100.0	134.4	160.0	145.7	155.5
	Minimum, mm	50.0	51.0	57.0	50.0	28.0
	Skewness	0.7	0.5	0.5	0.6	0.4
	Standard Deviation	38.4	53.2	56.7	72.7	81.2

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Patan * (148)	Coefficient of variation	0.5	0.6	0.6	0.6	0.5
	Kurtosis	0.4	4.8	7.2	2.8	-0.6
	Maximum, mm	146.1	275.6	351.8	315.0	183.2
	Mean, mm	60.2	78.6	94.1	98.3	88.2
	Median, mm	50.0	66.7	80.0	74.8	82.2
	Minimum, mm	11.2	13.0	22.2	17.2	19.9
	Skewness	1.0	2.0	2.4	1.5	0.7
	Standard Deviation	31.3	49.1	59.3	62.8	43.9
Pindwara (333)	Coefficient of variation	0.8	0.8	0.8	0.8	0.8
	Kurtosis	12.0	17.4	15.9	13.7	13.6
	Maximum, mm	635.0	965.2	996.9	1042.0	1073.0
	Mean, mm	124.2	168.6	189.8	204.4	199.8
	Median, mm	98.8	138.2	161.0	174.8	150.1
	Minimum, mm	31.7	25.6	31.7	31.7	36.8
	Skewness	3.0	3.7	3.4	3.1	3.2
	Standard Deviation	97.5	139.7	144.3	155.9	164.6
Pratap Garh (283)	Coefficient of variation	0.4	0.3	0.4	0.4	0.5
	Kurtosis	0.3	-0.8	-0.5	-0.3	0.3
	Maximum, mm	240.0	261.0	329.9	388.9	487.9
	Mean, mm	114.7	152.8	178.4	189.7	193.9
	Median, mm	112.2	143.8	168.6	179.5	173.6
	Minimum, mm	41.9	49.6	66.8	44.0	48.7
	Skewness	0.7	0.3	0.5	0.4	0.8
	Standard Deviation	42.3	52.4	63.6	79.2	95.7
Railmagra (80)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	0.4	0.2	0.0	-0.1	-0.4
	Maximum, mm	166.0	205.0	219.0	254.0	261.0
	Mean, mm	76.0	99.8	113.7	111.7	125.6
	Median, mm	70.0	91.0	104.0	104.0	110.5
	Minimum, mm	28.1	41.0	43.0	29.0	31.0
	Skewness	0.8	1.0	0.8	0.7	0.6
	Standard Deviation	30.1	41.5	44.3	53.9	60.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Rajsamand (81)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	5.6	1.0	0.7	0.1	0.0
	Maximum, mm	217.7	211.0	224.0	233.0	259.0
	Mean, mm	73.9	95.1	111.9	107.5	106.9
	Median, mm	66.0	86.5	105.7	105.3	110.2
	Minimum, mm	33.0	33.7	45.4	36.3	34.0
	Skewness	1.9	1.0	1.0	0.6	0.6
	Standard Deviation	31.9	37.3	41.3	46.6	52.8
Rashmi (72)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	5.1	0.6	0.7	-0.1	1.4
	Maximum, mm	234.2	245.9	291.8	310.0	332.0
	Mean, mm	88.5	117.0	137.1	130.6	130.3
	Median, mm	84.7	108.9	125.6	114.8	119.0
	Minimum, mm	28.0	35.3	39.6	34.0	41.0
	Skewness	1.8	1.0	1.0	0.8	1.3
	Standard Deviation	34.2	45.9	53.1	67.5	63.4
Rikhabdeo * (304)	Coefficient of variation	0.3	0.4	0.4	0.4	0.4
	Kurtosis	-0.8	0.9	1.3	1.4	1.1
	Maximum, mm	127.0	204.0	244.0	279.0	284.0
	Mean, mm	73.6	95.0	111.5	116.7	129.7
	Median, mm	75.5	91.5	104.8	110.9	122.5
	Minimum, mm	33.2	41.7	44.7	45.7	59.0
	Skewness	0.1	1.0	1.1	1.2	1.2
	Standard Deviation	24.0	34.5	39.9	51.3	54.8
Sahada (70)	Coefficient of variation	0.5	0.4	0.4	0.3	0.4
	Kurtosis	8.2	1.8	1.8	-0.6	-0.9
	Maximum, mm	262.9	247.0	265.4	195.0	224.0
	Mean, mm	83.6	101.4	121.3	114.4	123.4
	Median, mm	79.5	91.3	113.0	104.0	111.2
	Minimum, mm	39.0	52.0	71.0	30.5	43.0
	Skewness	2.4	1.2	1.4	0.2	0.4
	Standard Deviation	38.0	38.8	42.6	39.9	48.1

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sandesar * (98)	Coefficient of variation	0.4	0.5	0.4	0.5	0.6
	Kurtosis	0.7	1.5	0.5	0.3	0.9
	Maximum, mm	159.4	238.4	245.4	250.0	300.0
	Mean, mm	72.4	93.6	107.3	109.6	116.6
	Median, mm	70.0	86.0	99.0	101.5	109.0
	Minimum, mm	30.0	40.0	40.0	32.0	31.0
	Skewness	1.0	1.2	0.9	0.9	1.1
	Standard Deviation	30.6	42.4	46.2	52.1	66.9
Sarada (306)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	0.2	1.4	1.4	1.0	0.5
	Maximum, mm	159.0	223.0	261.0	281.0	304.6
	Mean, mm	77.1	99.2	114.9	116.5	123.9
	Median, mm	71.7	93.5	106.9	108.0	113.6
	Minimum, mm	38.0	40.0	53.6	34.0	37.0
	Skewness	0.8	1.2	1.2	1.1	0.9
	Standard Deviation	27.5	39.8	45.9	55.1	62.5
Sareri * (149)	Coefficient of variation	0.4	0.4	0.4	0.6	0.6
	Kurtosis	-0.3	1.7	2.1	1.3	0.8
	Maximum, mm	150.0	240.0	280.0	283.0	269.0
	Mean, mm	74.7	93.4	113.6	100.9	102.2
	Median, mm	72.0	87.0	104.6	97.6	96.0
	Minimum, mm	25.0	28.0	31.0	14.8	25.2
	Skewness	0.5	1.1	1.2	1.0	1.1
	Standard Deviation	32.1	41.2	48.7	59.1	60.0
Sarupsagar * (334)	Coefficient of variation	0.8	0.8	0.8	0.8	0.8
	Kurtosis	0.0	-0.4	-0.6	-0.8	-0.6
	Maximum, mm	225.0	264.2	281.3	287.1	360.0
	Mean, mm	68.6	89.6	100.1	109.0	124.1
	Median, mm	61.1	83.0	90.5	90.2	97.3
	Minimum, mm	0.1	0.1	0.1	0.1	0.2
	Skewness	0.7	0.5	0.4	0.5	0.5
	Standard Deviation	54.7	68.7	75.3	83.6	93.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Sawar (116)	Coefficient of variation	0.5	0.5	0.4	0.6	0.7
	Kurtosis	6.7	4.8	5.5	1.8	0.9
	Maximum, mm	275.0	312.0	336.0	343.0	369.0
	Mean, mm	84.1	98.8	115.1	115.4	125.1
	Median, mm	75.0	87.0	100.0	99.0	98.0
	Minimum, mm	40.0	12.0	40.0	33.6	25.0
	Skewness	2.2	1.8	2.0	1.4	1.3
	Standard Deviation	41.2	51.3	50.5	67.5	86.6
Shahpura (150)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	2.4	3.9	3.9	2.3	1.2
	Maximum, mm	214.0	289.0	350.0	318.0	370.0
	Mean, mm	87.5	114.5	131.4	128.0	140.1
	Median, mm	76.2	103.3	122.2	123.0	120.0
	Minimum, mm	38.0	46.3	55.6	47.0	48.4
	Skewness	1.6	1.9	1.8	1.4	1.2
	Standard Deviation	38.1	52.1	56.9	58.4	74.2
Som Ka Gadar * (307)	Coefficient of variation	0.5	0.5	0.5	0.6	0.5
	Kurtosis	0.6	0.6	2.1	0.8	0.1
	Maximum, mm	213.0	259.9	368.9	385.9	337.0
	Mean, mm	85.2	112.8	132.2	136.3	136.4
	Median, mm	75.0	95.1	117.0	113.5	113.7
	Minimum, mm	36.0	49.8	49.0	14.0	41.0
	Skewness	0.9	1.1	1.4	1.1	1.0
	Standard Deviation	38.4	51.7	64.6	78.4	72.6
Tatgarh (137)	Coefficient of variation	0.5	0.5	0.4	0.6	0.6
	Kurtosis	-0.3	0.3	0.1	0.3	-0.3
	Maximum, mm	200.0	252.0	291.0	317.0	282.0
	Mean, mm	87.9	108.0	129.5	117.8	124.0
	Median, mm	82.5	94.9	119.2	101.7	98.5
	Minimum, mm	18.0	18.8	20.8	18.1	27.0
	Skewness	0.6	0.8	0.7	1.0	0.9
	Standard Deviation	41.3	52.7	57.4	69.8	68.8

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Udaipur Dabok (a) (104)	Coefficient of variation	0.6	0.5	0.5	0.5	0.5
	Kurtosis	2.9	1.0	0.3	0.8	0.4
	Maximum, mm	225.8	254.2	255.0	286.8	310.4
	Mean, mm	74.4	97.3	113.0	119.1	127.3
	Median, mm	61.8	94.3	104.2	112.4	124.0
	Minimum, mm	22.7	35.0	35.0	38.5	15.6
	Skewness	1.7	1.2	1.0	1.1	0.9
	Standard Deviation	42.7	51.3	56.5	60.3	67.4
Ummed Sagar * (151)	Coefficient of variation	0.3	0.4	0.4	0.6	0.5
	Kurtosis	1.7	4.3	4.5	1.7	1.8
	Maximum, mm	165.0	272.0	287.0	314.0	360.0
	Mean, mm	76.4	98.5	113.5	113.0	135.7
	Median, mm	73.2	86.0	103.3	99.6	125.3
	Minimum, mm	39.0	44.0	46.0	10.3	52.0
	Skewness	1.0	1.8	1.9	1.1	1.3
	Standard Deviation	24.9	43.0	47.3	64.3	70.5
Vallabhnagar (108)	Coefficient of variation	0.4	0.4	0.4	0.6	0.6
	Kurtosis	0.0	3.0	2.5	0.7	-0.2
	Maximum, mm	164.0	286.0	316.0	322.0	349.0
	Mean, mm	84.8	110.0	125.8	117.8	133.7
	Median, mm	76.0	98.5	114.5	99.0	104.0
	Minimum, mm	36.0	48.8	52.5	21.3	24.4
	Skewness	0.8	1.6	1.5	1.2	1.0
	Standard Deviation	31.0	46.3	51.1	67.8	82.8
Vallabhnagar * (109)	Coefficient of variation	0.4	0.4	0.4	0.5	0.6
	Kurtosis	-0.4	2.1	0.7	0.2	-0.2
	Maximum, mm	142.0	265.0	270.0	272.0	305.0
	Mean, mm	82.2	107.0	122.7	125.5	132.2
	Median, mm	77.6	100.9	117.0	112.6	118.0
	Minimum, mm	0.5	0.6	0.6	0.7	0.7
	Skewness	0.0	0.9	0.6	0.8	0.8
	Standard Deviation	31.3	45.2	50.7	59.6	75.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Vijaynagar (138)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	2.3	0.3	0.8	-0.3	-0.3
	Maximum, mm	200.0	245.0	260.0	258.0	271.0
	Mean, mm	75.3	96.1	107.4	107.5	114.6
	Median, mm	63.9	81.0	86.5	94.5	99.9
	Minimum, mm	27.0	21.0	45.0	13.9	15.9
	Skewness	1.5	0.9	1.2	0.6	0.7
	Standard Deviation	38.0	50.2	50.4	61.0	66.9
West Banas * (336)	Coefficient of variation	0.9	0.9	0.9	0.9	1.0
	Kurtosis	6.1	8.4	6.7	6.5	9.0
	Maximum, mm	419.0	629.0	666.0	696.0	744.0
	Mean, mm	81.5	111.9	129.8	135.0	138.0
	Median, mm	72.0	108.0	123.7	134.6	107.2
	Minimum, mm	0.1	0.1	0.1	0.1	0.2
	Skewness	1.9	2.2	1.9	1.9	2.4
	Standard Deviation	73.8	105.7	114.6	123.1	131.4
ACZ IVb						
Arnod (3)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	2.4	-0.2	-0.8	-1.1	-0.4
	Maximum, mm	310.0	317.0	359.0	395.0	505.0
	Mean, mm	129.5	173.6	200.6	213.2	230.8
	Median, mm	122.4	164.0	192.0	192.4	217.0
	Minimum, mm	40.5	63.2	76.5	74.5	77.5
	Skewness	1.4	0.5	0.3	0.3	0.5
	Standard Deviation	54.1	61.2	71.7	86.4	100.2
Arthuna (264)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	2.1	2.0	2.1	1.5	-0.3
	Maximum, mm	363.0	478.0	521.0	551.0	453.0
	Mean, mm	129.9	168.7	188.1	196.5	183.9
	Median, mm	124.4	163.2	186.2	199.5	151.5
	Minimum, mm	47.2	59.7	59.7	36.9	31.7
	Skewness	1.1	1.2	1.1	0.9	0.6
	Standard Deviation	61.6	81.7	87.4	100.2	99.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Aspur (290)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	1.5	0.7	0.1	-0.1	1.2
	Maximum, mm	303.0	352.4	368.0	397.0	437.0
	Mean, mm	109.2	143.2	163.3	165.0	153.2
	Median, mm	99.5	121.6	141.5	144.8	136.0
	Minimum, mm	43.0	50.8	55.9	24.1	23.0
	Skewness	1.2	1.2	0.9	0.8	1.1
	Standard Deviation	54.5	76.5	78.7	88.6	85.0
Bagidora (310)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	0.2	-0.4	-0.3	-0.9	-0.6
	Maximum, mm	311.0	400.0	442.0	374.0	392.0
	Mean, mm	147.7	194.4	212.2	213.2	208.7
	Median, mm	146.0	196.9	206.0	207.9	211.5
	Minimum, mm	55.0	74.5	81.0	51.4	40.0
	Skewness	0.6	0.3	0.4	0.0	0.0
	Standard Deviation	57.2	76.2	80.7	78.7	80.6
Banswara (266)	Coefficient of variation	0.5	0.6	0.5	0.5	0.6
	Kurtosis	-0.4	0.4	0.7	1.2	2.0
	Maximum, mm	405.0	600.0	657.0	712.0	766.0
	Mean, mm	170.0	235.1	258.5	266.6	261.6
	Median, mm	132.5	197.3	213.8	220.1	217.2
	Minimum, mm	59.2	75.0	86.0	91.4	93.9
	Skewness	0.8	1.0	1.2	1.3	1.5
	Standard Deviation	92.6	132.7	140.2	146.0	145.9
Banswara (a) (265)	Coefficient of variation	0.6	0.5	0.5	0.6	0.5
	Kurtosis	0.2	0.5	1.3	1.9	-0.6
	Maximum, mm	403.9	514.7	579.7	620.7	403.8
	Mean, mm	146.7	190.2	209.5	211.3	207.5
	Median, mm	120.8	158.0	180.6	182.4	183.8
	Minimum, mm	51.0	65.0	68.7	43.5	48.4
	Skewness	1.1	1.0	1.1	1.2	0.6
	Standard Deviation	88.6	104.5	110.6	118.6	95.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bhungra (267)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	-0.8	-0.6	-0.4	-0.4	-0.5
	Maximum, mm	254.0	371.0	402.0	428.0	433.0
	Mean, mm	129.8	178.0	201.8	215.9	209.6
	Median, mm	116.0	158.0	174.4	210.0	195.0
	Minimum, mm	28.7	39.1	39.1	91.8	20.6
	Skewness	0.4	0.5	0.6	0.7	0.4
	Standard Deviation	54.8	76.1	84.4	84.1	96.0
Danpur (268)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	0.5	0.3	2.6	3.2	4.9
	Maximum, mm	388.0	505.0	705.0	785.0	845.0
	Mean, mm	146.6	207.7	235.5	251.4	241.1
	Median, mm	130.0	191.8	214.5	231.8	231.0
	Minimum, mm	37.2	60.0	73.7	75.0	71.6
	Skewness	0.9	0.9	1.4	1.5	1.7
	Standard Deviation	80.1	108.7	124.6	134.3	137.6
Dewal (292)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	3.3	8.4	8.7	-0.4	0.0
	Maximum, mm	165.1	295.9	346.7	204.0	226.6
	Mean, mm	69.7	94.1	110.9	105.2	103.9
	Median, mm	63.8	85.0	104.0	97.5	93.0
	Minimum, mm	28.0	40.0	44.0	47.0	20.9
	Skewness	1.7	2.4	2.3	0.6	0.6
	Standard Deviation	27.1	41.7	47.9	38.6	42.7
Dhambola (322)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	-0.4	0.4	0.3	-0.1	-0.5
	Maximum, mm	234.3	355.4	376.0	434.0	417.8
	Mean, mm	108.6	155.0	172.8	182.0	188.4
	Median, mm	100.5	146.9	165.4	175.5	191.0
	Minimum, mm	31.7	40.1	51.8	39.1	32.0
	Skewness	0.6	0.8	0.8	0.7	0.4
	Standard Deviation	48.4	71.7	77.7	94.4	94.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dhariawad (288)	Coefficient of variation	0.5	0.6	0.5	0.6	0.6
	Kurtosis	1.5	4.9	5.5	3.6	3.3
	Maximum, mm	308.8	523.6	603.2	612.6	632.8
	Mean, mm	119.2	156.9	180.1	190.8	195.6
	Median, mm	104.0	131.4	159.1	166.0	173.2
	Minimum, mm	45.8	68.0	81.0	78.2	50.7
	Skewness	1.3	2.0	2.0	1.7	1.7
	Standard Deviation	57.5	87.8	97.3	107.3	114.4
Dungarpur (294)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	1.4	1.6	3.0	2.3	1.3
	Maximum, mm	247.0	337.8	433.1	438.3	440.3
	Mean, mm	101.6	138.7	158.6	160.8	173.5
	Median, mm	96.2	127.6	144.4	141.7	160.0
	Minimum, mm	37.0	56.0	70.2	41.4	51.0
	Skewness	1.0	1.3	1.5	1.2	1.0
	Standard Deviation	41.0	61.6	71.0	76.1	79.0
Galiakot (308)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	-0.3	0.7	0.4	0.8	1.7
	Maximum, mm	302.0	461.0	485.4	529.4	545.0
	Mean, mm	131.9	173.4	195.1	189.7	181.4
	Median, mm	116.8	161.9	178.5	160.5	148.2
	Minimum, mm	37.0	62.0	71.7	33.0	33.0
	Skewness	0.7	1.0	0.9	1.1	1.3
	Standard Deviation	66.6	90.3	97.4	111.7	111.8
Ganeshpur (295)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	0.7	-0.1	-0.3	-0.2	-0.6
	Maximum, mm	235.0	299.0	319.0	333.0	312.0
	Mean, mm	99.3	132.2	147.0	138.9	135.5
	Median, mm	91.5	131.0	145.4	129.5	105.1
	Minimum, mm	25.9	25.4	39.2	22.0	32.6
	Skewness	0.9	0.5	0.4	0.5	0.6
	Standard Deviation	43.9	60.3	61.4	71.4	72.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Garhi (269)	Coefficient of variation	0.6	0.5	0.5	0.5	0.5
	Kurtosis	8.3	2.7	1.3	0.6	-0.1
	Maximum, mm	490.0	509.0	513.0	515.0	435.7
	Mean, mm	130.7	170.6	189.4	194.6	180.2
	Median, mm	116.6	139.3	163.8	163.5	146.0
	Minimum, mm	55.0	62.0	75.7	24.7	25.0
	Skewness	2.4	1.4	1.2	1.0	0.7
	Standard Deviation	73.5	86.9	93.4	104.0	95.2
Ghatol (270)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	0.2	0.2	0.9	2.0	1.1
	Maximum, mm	339.0	449.0	529.0	584.0	536.0
	Mean, mm	135.4	181.0	204.1	214.1	200.6
	Median, mm	126.8	164.0	186.8	198.0	165.0
	Minimum, mm	46.7	56.0	85.1	80.0	44.6
	Skewness	0.8	0.9	1.0	1.3	1.1
	Standard Deviation	64.2	86.8	94.7	101.5	100.5
Jagpura (271)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	-0.3	-0.4	0.0	1.0	2.8
	Maximum, mm	240.0	361.6	396.6	480.6	544.6
	Mean, mm	109.4	149.6	172.8	179.6	180.9
	Median, mm	98.0	123.0	147.5	146.2	153.0
	Minimum, mm	25.4	38.1	38.1	35.6	31.0
	Skewness	0.8	0.8	0.9	1.2	1.7
	Standard Deviation	53.6	75.5	84.7	97.1	100.3
Kanba (323)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	-0.6	-0.3	0.5	1.2	0.3
	Maximum, mm	167.0	227.0	283.0	309.0	314.5
	Mean, mm	88.5	118.1	134.4	133.1	143.7
	Median, mm	82.0	109.3	126.8	121.8	131.9
	Minimum, mm	26.0	44.0	26.0	13.0	43.0
	Skewness	0.5	0.7	0.8	1.1	0.9
	Standard Deviation	36.0	47.5	52.4	58.6	66.1

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kushalgarh (312)	Coefficient of variation	0.4	0.4	0.4	0.4	0.4
	Kurtosis	-0.4	-0.7	-0.7	-0.7	0.1
	Maximum, mm	290.0	373.0	431.0	445.0	487.0
	Mean, mm	140.4	186.8	210.0	215.3	214.4
	Median, mm	130.8	164.8	183.0	192.5	203.0
	Minimum, mm	40.1	49.0	72.0	46.0	47.0
	Skewness	0.6	0.5	0.5	0.4	0.7
	Standard Deviation	59.7	78.5	84.8	90.7	96.1
Loharia (273)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	0.3	0.0	-0.2	1.1	2.6
	Maximum, mm	250.2	335.0	364.0	446.0	516.0
	Mean, mm	107.4	141.9	162.1	159.2	159.8
	Median, mm	103.0	134.5	146.0	130.5	132.6
	Minimum, mm	39.0	53.0	62.0	50.9	36.4
	Skewness	0.9	0.8	0.8	1.3	1.5
	Standard Deviation	49.0	67.5	78.3	90.3	96.2
Mahi Dam * (274)	Coefficient of variation	0.6	0.5	0.5	0.5	0.5
	Kurtosis	-0.1	-0.8	-0.8	-0.8	-0.5
	Maximum, mm	335.0	401.5	446.0	462.0	467.0
	Mean, mm	139.8	186.6	208.7	223.8	227.6
	Median, mm	125.0	173.7	198.0	201.0	192.9
	Minimum, mm	39.0	62.0	63.3	51.0	52.0
	Skewness	0.8	0.6	0.6	0.6	0.7
	Standard Deviation	77.9	95.9	103.2	109.7	113.3
Nithawa (296)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	1.1	0.2	-0.5	-1.0	-0.9
	Maximum, mm	262.6	340.8	340.8	327.0	393.0
	Mean, mm	100.8	130.7	149.6	162.3	172.7
	Median, mm	80.0	110.4	131.0	143.0	158.5
	Minimum, mm	38.1	45.5	48.3	56.3	24.0
	Skewness	1.3	1.0	0.8	0.6	0.5
	Standard Deviation	54.0	71.0	74.1	80.5	98.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Pipalkhunt (275)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	-1.0	0.6	0.1	0.0	0.3
	Maximum, mm	225.0	426.8	439.0	470.7	516.0
	Mean, mm	130.2	180.4	201.2	215.7	217.3
	Median, mm	121.8	151.5	171.6	198.0	197.6
	Minimum, mm	65.0	75.0	85.0	59.0	68.0
	Skewness	0.5	1.1	1.0	0.8	1.0
	Standard Deviation	49.5	82.9	89.6	104.3	109.6
Sabla (297)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	0.4	-0.3	0.1	-0.1	-1.3
	Maximum, mm	250.0	310.0	366.0	399.0	327.0
	Mean, mm	100.0	130.7	148.3	157.4	165.3
	Median, mm	84.9	114.5	122.9	141.0	138.0
	Minimum, mm	40.6	43.2	50.8	41.0	48.0
	Skewness	1.0	0.7	0.8	0.7	0.4
	Standard Deviation	47.8	66.4	70.3	80.8	85.1
Sagwara (309)	Coefficient of variation	0.6	0.5	0.5	0.5	0.5
	Kurtosis	3.2	3.1	3.2	2.6	0.3
	Maximum, mm	384.0	494.0	532.0	581.0	415.0
	Mean, mm	125.3	162.5	182.2	189.4	173.2
	Median, mm	103.5	134.2	159.9	171.2	155.6
	Minimum, mm	42.0	47.0	80.0	45.0	51.0
	Skewness	1.7	1.5	1.5	1.3	1.0
	Standard Deviation	69.7	83.2	86.6	101.3	87.5
Sajjangarh (820)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.4	0.6	1.4	1.3	1.1
	Maximum, mm	318.0	399.0	490.0	497.0	505.0
	Mean, mm	122.6	164.5	185.6	188.6	187.8
	Median, mm	112.2	145.5	163.2	168.4	168.1
	Minimum, mm	40.0	52.0	56.0	60.0	23.0
	Skewness	1.1	1.0	1.1	1.1	1.0
	Standard Deviation	60.0	76.8	85.6	90.0	97.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Salumber (305)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	0.4	1.4	1.1	0.5	0.7
	Maximum, mm	229.6	338.4	358.8	355.4	395.0
	Mean, mm	102.1	136.8	153.0	148.5	154.4
	Median, mm	92.6	119.0	130.5	134.0	136.0
	Minimum, mm	41.7	53.1	64.5	23.0	33.7
	Skewness	0.9	1.3	1.2	0.9	0.9
	Standard Deviation	39.4	60.8	67.5	71.4	82.8
Shergarh (314)	Coefficient of variation	0.5	0.4	0.4	0.5	0.5
	Kurtosis	-0.5	-1.1	-1.0	-0.9	-1.0
	Maximum, mm	275.0	334.2	382.4	400.4	414.4
	Mean, mm	125.9	172.6	190.2	193.5	191.4
	Median, mm	128.5	160.3	182.2	189.3	162.4
	Minimum, mm	0.0	54.0	58.0	39.0	49.0
	Skewness	0.2	0.2	0.3	0.3	0.5
	Standard Deviation	62.1	72.7	83.7	93.6	103.0
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Aklera (26)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	0.3	0.5	0.2	0.0	-0.6
	Maximum, mm	259.0	364.0	392.0	413.0	435.0
	Mean, mm	117.8	159.4	186.5	197.9	204.8
	Median, mm	108.7	145.2	167.2	172.0	195.6
	Minimum, mm	55.9	72.9	86.2	72.5	41.9
	Skewness	1.1	1.1	1.0	1.0	0.7
	Standard Deviation	48.4	69.3	78.9	88.8	99.8
Asnawar (31)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.5	0.3	0.0	-0.1	0.1
	Maximum, mm	314.0	393.9	443.0	471.0	524.0
	Mean, mm	117.8	164.3	192.0	207.4	218.3
	Median, mm	102.8	132.5	162.8	182.8	191.3
	Minimum, mm	23.1	27.4	32.5	32.1	18.7
	Skewness	1.2	1.0	0.9	0.9	0.9
	Standard Deviation	61.5	89.8	99.7	103.8	107.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Atru (59)	Coefficient of variation	0.4	0.4	0.4	0.4	0.5
	Kurtosis	0.0	-0.2	-0.7	-0.8	-0.8
	Maximum, mm	236.5	353.3	370.6	367.2	370.2
	Mean, mm	116.8	161.0	180.9	183.8	187.9
	Median, mm	106.4	136.2	150.6	155.2	156.7
	Minimum, mm	48.3	65.0	80.0	38.0	47.0
	Skewness	0.8	0.8	0.8	0.6	0.6
	Standard Deviation	47.1	67.1	76.7	82.6	88.5
Bakani (32)	Coefficient of variation	0.5	0.6	0.6	0.5	0.5
	Kurtosis	0.4	2.5	1.0	0.2	0.5
	Maximum, mm	289.0	542.6	577.1	537.0	589.0
	Mean, mm	123.2	175.7	207.3	211.3	232.5
	Median, mm	103.7	139.7	173.8	197.6	218.6
	Minimum, mm	53.5	58.2	75.2	43.4	51.8
	Skewness	1.1	1.5	1.2	0.9	0.9
	Standard Deviation	60.9	99.7	114.7	115.7	115.8
Baran (60)	Coefficient of variation	0.6	0.5	0.6	0.6	0.6
	Kurtosis	4.8	1.0	1.4	2.9	2.3
	Maximum, mm	413.2	418.8	503.0	573.0	612.0
	Mean, mm	119.6	164.8	185.4	183.0	191.7
	Median, mm	104.0	144.0	160.0	164.8	171.1
	Minimum, mm	40.0	48.2	66.0	67.8	33.0
	Skewness	1.9	1.3	1.4	1.7	1.5
	Standard Deviation	69.1	89.3	102.1	105.5	116.4
Bhimsagar * (33)	Coefficient of variation	0.7	0.6	0.5	0.5	0.5
	Kurtosis	1.8	0.2	0.2	0.3	0.4
	Maximum, mm	225.0	256.0	287.0	296.0	303.0
	Mean, mm	74.3	100.6	115.2	121.8	128.1
	Median, mm	63.1	82.6	97.9	105.5	109.8
	Minimum, mm	18.7	27.4	33.9	29.0	13.0
	Skewness	1.4	1.0	1.0	1.0	0.9
	Standard Deviation	48.4	57.3	61.8	64.0	66.7

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Bundi (48)	Coefficient of variation	0.4	0.5	0.5	0.6	0.6
	Kurtosis	2.6	6.2	6.0	3.0	2.8
	Maximum, mm	258.0	445.0	497.0	509.0	525.0
	Mean, mm	99.4	136.7	157.7	154.7	161.0
	Median, mm	87.0	123.8	147.0	138.2	140.6
	Minimum, mm	45.7	38.0	63.4	19.0	24.6
	Skewness	1.5	2.0	2.0	1.4	1.5
	Standard Deviation	41.1	67.2	74.7	89.8	97.3
Chandsen * (162)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	1.3	1.7	2.6	2.3	2.4
	Maximum, mm	201.9	301.3	354.1	399.2	430.3
	Mean, mm	75.5	97.5	114.7	124.5	144.7
	Median, mm	73.7	84.0	102.4	108.5	140.0
	Minimum, mm	25.0	23.0	32.0	25.0	28.0
	Skewness	1.1	1.3	1.5	1.4	1.4
	Standard Deviation	37.8	58.5	65.0	79.5	88.1
Chhabra (61)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	0.3	2.1	2.5	1.0	0.3
	Maximum, mm	267.0	406.0	492.0	500.0	504.0
	Mean, mm	122.3	165.0	193.9	202.2	218.8
	Median, mm	113.0	156.5	184.5	185.5	202.4
	Minimum, mm	35.0	49.2	53.2	47.0	42.0
	Skewness	0.7	1.1	1.2	1.0	0.7
	Standard Deviation	46.5	65.3	78.8	93.1	100.7
Chhipabarod (62)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.9	1.3	2.4	1.2	0.6
	Maximum, mm	311.0	429.0	492.0	507.0	520.0
	Mean, mm	118.0	160.0	187.9	195.7	200.3
	Median, mm	109.8	144.0	161.4	162.0	160.7
	Minimum, mm	48.0	50.0	53.0	55.0	46.0
	Skewness	1.4	1.0	1.4	1.1	1.0
	Standard Deviation	56.5	75.5	89.8	101.9	109.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Dheel * (178)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	3.8	0.5	-0.2	0.3	1.4
	Maximum, mm	292.0	301.0	342.0	453.0	513.0
	Mean, mm	92.8	130.8	151.5	169.5	178.4
	Median, mm	82.0	117.0	121.9	129.6	139.9
	Minimum, mm	18.0	23.0	28.0	30.0	51.9
	Skewness	1.5	0.9	0.7	0.9	1.2
	Standard Deviation	49.2	61.7	73.8	97.2	103.3
Digod (12)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	-0.1	1.6	1.0	0.2	-0.3
	Maximum, mm	227.0	403.0	416.0	428.0	452.0
	Mean, mm	107.4	151.0	168.7	180.6	186.7
	Median, mm	100.0	127.5	152.1	163.0	157.5
	Minimum, mm	23.6	34.6	39.6	51.7	49.0
	Skewness	0.7	1.2	1.1	0.9	0.8
	Standard Deviation	46.8	70.5	75.6	84.4	102.1
Dug (34)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	1.3	2.6	2.3	1.3	0.7
	Maximum, mm	303.0	502.4	574.4	582.8	588.0
	Mean, mm	117.4	164.6	189.2	195.3	213.6
	Median, mm	106.6	139.5	168.4	169.6	179.2
	Minimum, mm	45.0	41.2	54.2	48.2	29.2
	Skewness	1.2	1.6	1.5	1.3	1.2
	Standard Deviation	55.0	97.2	108.7	121.2	133.5
Gangdhar (25)	Coefficient of variation	0.5	0.6	0.5	0.5	0.6
	Kurtosis	3.0	5.7	3.0	-0.4	0.5
	Maximum, mm	335.8	559.6	564.0	389.4	507.0
	Mean, mm	114.4	158.4	179.5	175.1	182.1
	Median, mm	100.5	136.4	146.0	149.4	168.0
	Minimum, mm	48.0	61.5	62.3	27.2	52.8
	Skewness	1.3	1.9	1.5	0.7	1.0
	Standard Deviation	54.0	88.2	94.6	91.9	102.9

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Gudha Dam * (49)	Coefficient of variation	0.5	0.6	0.6	0.6	0.6
	Kurtosis	0.6	1.2	2.1	1.4	1.5
	Maximum, mm	217.0	333.0	415.0	428.6	436.6
	Mean, mm	84.3	119.7	143.3	148.5	150.4
	Median, mm	80.3	111.7	131.0	128.0	119.7
	Minimum, mm	19.0	35.5	37.8	36.2	38.8
	Skewness	0.8	1.2	1.5	1.3	1.4
	Standard Deviation	42.4	69.7	84.0	90.6	95.3
Hindoli (50)	Coefficient of variation	0.4	0.5	0.5	0.5	0.4
	Kurtosis	0.3	0.1	0.9	0.7	-0.1
	Maximum, mm	196.0	275.0	362.4	367.4	293.8
	Mean, mm	89.9	120.6	140.8	145.2	141.4
	Median, mm	83.5	114.0	140.5	134.2	137.0
	Minimum, mm	29.0	40.4	41.0	41.6	49.0
	Skewness	0.8	0.7	0.9	0.9	0.7
	Standard Deviation	39.4	55.3	65.7	73.0	61.7
Jhalawar (36)	Coefficient of variation	0.4	0.5	0.5	0.5	0.6
	Kurtosis	4.1	1.1	0.1	0.8	1.4
	Maximum, mm	350.2	432.0	450.9	565.4	647.4
	Mean, mm	121.8	167.8	196.9	211.3	212.7
	Median, mm	107.2	140.0	170.0	176.5	184.0
	Minimum, mm	57.0	53.0	81.0	63.0	37.0
	Skewness	1.6	1.1	0.9	1.0	1.1
	Standard Deviation	53.3	81.4	90.6	105.4	119.5
Jhalrapatan (37)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	6.1	2.8	1.5	2.1	2.4
	Maximum, mm	410.7	498.6	523.0	633.6	714.8
	Mean, mm	119.4	168.8	199.7	212.8	223.8
	Median, mm	103.8	132.9	167.5	172.0	186.2
	Minimum, mm	45.6	70.0	79.3	32.6	45.0
	Skewness	2.0	1.6	1.3	1.4	1.4
	Standard Deviation	63.4	90.2	101.0	117.5	131.6

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Khandar (120)	Coefficient of variation	0.5	0.6	0.6	0.7	0.7
	Kurtosis	4.4	10.5	15.7	14.0	12.6
	Maximum, mm	278.0	520.0	670.0	755.0	772.0
	Mean, mm	92.3	128.2	152.2	166.7	169.1
	Median, mm	84.0	109.5	131.5	142.5	143.6
	Minimum, mm	41.0	43.0	56.0	25.0	29.0
	Skewness	1.9	2.8	3.4	3.2	3.1
	Standard Deviation	45.3	77.9	93.0	109.7	116.8
Khanpur (38)	Coefficient of variation	0.4	0.4	0.4	0.6	0.6
	Kurtosis	1.2	0.4	0.0	-0.2	-0.8
	Maximum, mm	285.0	362.2	403.0	418.0	449.6
	Mean, mm	114.0	149.6	174.1	168.0	186.5
	Median, mm	102.2	131.4	155.2	143.1	156.7
	Minimum, mm	45.0	50.2	60.4	31.6	37.2
	Skewness	1.1	0.9	0.8	0.7	0.5
	Standard Deviation	50.5	67.1	75.9	96.9	112.7
Kishanganj (63)	Coefficient of variation	0.4	0.5	0.5	0.5	0.5
	Kurtosis	1.3	0.7	0.2	0.0	0.4
	Maximum, mm	262.8	361.7	415.1	431.4	481.0
	Mean, mm	106.1	145.1	170.5	178.3	196.7
	Median, mm	92.7	125.0	143.6	154.0	160.7
	Minimum, mm	41.0	47.0	47.0	21.9	90.0
	Skewness	1.3	1.1	1.0	0.9	1.1
	Standard Deviation	47.5	68.5	83.9	91.8	98.1
Kota A.p. (a) (15)	Coefficient of variation	0.5	0.5	0.5	0.5	0.6
	Kurtosis	-0.3	2.5	1.3	0.2	0.2
	Maximum, mm	217.3	383.4	390.5	391.9	434.4
	Mean, mm	99.2	134.7	151.9	161.8	171.5
	Median, mm	86.9	129.6	150.7	142.6	158.1
	Minimum, mm	0.1	0.1	0.2	0.3	0.3
	Skewness	0.2	0.7	0.4	0.4	0.5
	Standard Deviation	52.0	70.7	76.5	88.8	99.0

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Kota Barrage * (17)	Coefficient of variation	0.5	0.6	0.5	0.6	0.6
	Kurtosis	-0.2	2.5	1.4	0.1	0.1
	Maximum, mm	217.2	383.2	390.2	391.6	433.6
	Mean, mm	94.6	123.9	142.5	153.5	160.3
	Median, mm	89.8	117.8	141.0	134.0	141.0
	Minimum, mm	0.1	0.1	0.2	0.3	0.3
	Skewness	0.3	0.9	0.6	0.6	0.6
	Standard Deviation	50.2	70.3	75.2	90.4	102.9
Ladpura (19)	Coefficient of variation	0.4	0.5	0.4	0.5	0.5
	Kurtosis	1.2	4.4	3.6	2.3	2.2
	Maximum, mm	217.0	409.2	419.2	422.4	432.9
	Mean, mm	97.7	132.8	152.0	152.5	159.1
	Median, mm	91.1	117.4	137.0	137.6	141.8
	Minimum, mm	42.0	25.0	60.2	32.0	34.7
	Skewness	1.2	1.8	1.6	1.3	1.5
	Standard Deviation	43.5	69.2	68.2	75.3	85.3
Mangrol (64)	Coefficient of variation	0.4	0.4	0.4	0.5	0.5
	Kurtosis	-0.3	1.1	1.7	2.1	1.6
	Maximum, mm	200.0	325.0	425.0	478.0	497.0
	Mean, mm	103.1	134.3	160.1	167.6	169.6
	Median, mm	92.6	123.1	146.2	153.2	161.0
	Minimum, mm	35.0	49.0	59.0	29.0	36.0
	Skewness	0.7	1.0	1.2	1.2	1.0
	Standard Deviation	40.1	55.5	71.6	81.9	89.3
Mansarowar * (21)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	1.1	0.4	0.4	1.1	0.9
	Maximum, mm	250.0	311.0	371.0	446.0	450.0
	Mean, mm	101.1	140.5	164.8	177.7	184.0
	Median, mm	88.5	119.0	141.6	157.5	165.0
	Minimum, mm	42.0	57.0	57.0	10.0	47.0
	Skewness	1.3	1.2	1.1	1.0	1.0
	Standard Deviation	51.0	68.8	78.0	86.5	89.5

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Nainwa (51)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	1.3	1.1	1.1	1.9	1.4
	Maximum, mm	232.0	319.0	339.0	359.0	379.0
	Mean, mm	91.5	113.7	127.0	115.8	125.7
	Median, mm	82.0	102.5	108.8	104.5	111.6
	Minimum, mm	34.0	30.2	45.0	10.0	11.0
	Skewness	1.3	1.2	1.2	1.3	1.2
	Standard Deviation	44.9	60.9	63.2	68.2	79.5
Pachpahar (40)	Coefficient of variation	0.4	0.4	0.5	0.5	0.5
	Kurtosis	0.4	0.7	1.1	0.3	0.1
	Maximum, mm	260.6	358.6	461.8	482.3	498.1
	Mean, mm	112.6	157.1	183.8	189.6	207.4
	Median, mm	101.0	144.5	179.1	162.8	187.5
	Minimum, mm	33.1	53.4	53.4	37.6	45.0
	Skewness	0.9	1.0	1.1	0.9	0.8
	Standard Deviation	48.6	68.1	83.0	99.1	107.7
Pipalda (65)	Coefficient of variation	0.5	0.4	0.5	0.5	0.5
	Kurtosis	1.8	1.2	1.1	0.4	0.1
	Maximum, mm	260.0	302.0	389.0	405.0	428.5
	Mean, mm	100.4	130.7	159.6	161.5	168.8
	Median, mm	95.7	118.2	140.5	143.3	147.5
	Minimum, mm	36.0	47.0	47.0	43.7	40.0
	Skewness	1.4	1.2	1.1	0.9	0.8
	Standard Deviation	47.6	58.8	74.7	83.3	86.7
Pirawa (39)	Coefficient of variation	0.4	0.5	0.5	0.5	0.6
	Kurtosis	1.0	0.2	-0.1	0.3	0.8
	Maximum, mm	320.0	440.0	483.0	554.0	589.0
	Mean, mm	133.3	187.0	214.5	219.0	211.9
	Median, mm	119.0	170.4	192.7	188.4	171.4
	Minimum, mm	49.5	76.2	81.2	44.0	55.4
	Skewness	0.9	0.9	0.9	0.9	1.2
	Standard Deviation	54.7	85.6	103.2	111.8	121.3

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Ramganjmandi (45)	Coefficient of variation	0.5	0.5	0.5	0.6	0.6
	Kurtosis	4.0	1.1	2.4	2.1	1.3
	Maximum, mm	378.0	406.3	518.7	569.1	571.3
	Mean, mm	123.6	163.6	185.3	185.2	200.7
	Median, mm	113.5	158.5	175.2	160.2	159.0
	Minimum, mm	36.8	55.0	67.4	35.6	38.9
	Skewness	1.7	1.1	1.4	1.3	1.2
	Standard Deviation	61.1	80.0	89.8	107.8	113.6
Sangod (46)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	0.4	4.0	4.9	2.9	1.2
	Maximum, mm	291.5	483.5	562.5	570.5	540.8
	Mean, mm	116.2	153.3	174.8	185.2	191.3
	Median, mm	98.3	129.5	152.5	170.0	194.5
	Minimum, mm	26.0	35.0	45.0	38.0	38.0
	Skewness	1.0	1.6	1.7	1.4	0.8
	Standard Deviation	55.8	78.8	88.1	100.8	99.0
Sawai Madhopur (122)	Coefficient of variation	0.5	0.5	0.5	0.5	0.5
	Kurtosis	5.8	6.2	4.8	2.3	2.1
	Maximum, mm	356.2	489.4	538.6	560.2	585.6
	Mean, mm	110.7	152.8	181.9	195.3	221.7
	Median, mm	93.5	133.6	156.3	169.1	205.0
	Minimum, mm	40.0	50.0	80.0	35.0	56.0
	Skewness	2.1	2.2	2.0	1.4	1.4
	Standard Deviation	56.1	79.7	91.1	107.4	109.5
Talera (52)	Coefficient of variation	0.4	0.5	0.5	0.5	0.5
	Kurtosis	1.0	8.5	7.8	-0.3	0.4
	Maximum, mm	240.0	458.0	493.0	328.0	402.0
	Mean, mm	96.7	132.4	150.0	134.8	148.3
	Median, mm	85.1	124.0	143.8	121.8	130.0
	Minimum, mm	28.0	32.0	32.0	26.0	30.9
	Skewness	1.1	2.2	2.1	0.6	0.9
	Standard Deviation	43.1	66.2	71.3	73.1	81.4

Station Name (WRIS Code)	Parameter	Consecutive Days of Maximum Rainfall				
		1 day	2 day	3 day	4 day	5 day
Ummed Sagar * (66)	Coefficient of variation	1.6	0.5	0.4	0.5	0.4
	Kurtosis	2.4	-0.9	-0.9	-0.9	-0.8
	Maximum, mm	272.0	294.0	302.0	373.0	383.0
	Mean, mm	39.5	154.9	174.1	184.0	211.1
	Median, mm	0.0	125.0	154.0	173.4	193.0
	Minimum, mm	0.0	71.0	71.0	33.0	58.0
	Skewness	1.7	0.8	0.5	0.3	0.2
	Standard Deviation	64.6	70.9	69.4	92.9	88.1

(a)=IMD stations; *= Water resources Dept. Stations; No suffix= Revenue Dept. Stations
Source: WRD Daily Rainfall Data, 1957-2010

Appendix 11

Block-wise Mean Monthly Evaporation

Block-Wise Mean Monthly Evaporation, cm

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Abu Road	7.3	9.3	16.5	23.3	31.6	26.0	16.7	12.8	12.7	12.5	8.8	6.9	184.4
Ahore	7.5	9.4	16.7	23.1	31.5	26.3	17.7	13.7	13.3	12.9	8.9	6.9	187.8
Alsisar	6.8	9.2	17.3	26.1	32.6	28.0	21.1	19.2	17.8	15.1	9.4	6.5	209.1
Amber	8.3	11.5	19.5	27.3	36.4	33.6	20.2	15.5	17.4	16.8	11.4	8.7	226.7
Amet	8.0	10.2	17.8	25.3	33.6	27.9	17.4	13.0	13.4	13.4	9.6	7.5	197.1
Anandpuri	9.9	11.1	17.9	25.7	37.1	33.4	21.0	13.2	13.7	14.0	11.9	10.4	219.3
Antah	8.6	10.9	19.6	28.1	37.4	31.6	18.7	12.4	13.8	14.5	10.9	8.4	215.0
Anupgarh	6.3	8.7	16.0	24.0	31.7	28.8	22.4	19.9	17.6	14.9	9.1	6.3	205.8
Arain	8.4	11.1	19.2	27.0	35.7	31.4	19.5	14.5	15.6	15.4	11.0	8.5	217.1
Arnod	9.8	11.1	18.0	25.8	36.9	33.0	20.6	13.0	13.6	14.0	11.8	10.2	217.7
Asind	8.5	10.8	18.7	26.4	34.8	29.7	18.8	13.9	14.4	14.5	10.5	8.2	209.3
Aspur	9.4	10.9	18.1	26.0	36.4	32.0	19.9	13.0	13.6	13.9	11.4	9.7	214.3
Atru	8.6	10.9	19.3	27.5	36.6	31.0	18.3	12.3	13.6	14.4	10.9	8.5	211.9
Bagidora	10.0	11.1	17.9	25.7	37.3	33.8	21.3	13.2	13.6	14.0	12.1	10.7	220.8
Bakani	8.7	11.0	19.0	26.9	35.8	30.4	18.0	12.1	13.4	14.2	10.9	8.6	209.1
Balesar	10.4	12.8	21.9	29.9	37.8	33.2	24.0	18.7	18.0	17.7	12.6	9.8	247.0
Bali	5.8	7.6	14.0	19.7	28.3	22.7	14.3	11.3	10.7	10.1	6.5	5.1	155.9
Balotra	10.0	12.1	19.9	27.1	34.5	30.4	22.6	17.6	17.4	17.3	12.5	9.7	231.1
Bamanwas	8.3	11.2	19.3	27.2	36.2	32.4	19.8	14.8	16.2	15.9	11.1	8.5	220.8

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Bandikui	8.2	11.2	19.2	27.1	35.9	32.4	20.0	15.4	16.7	16.1	11.0	8.4	221.5
Banera	8.5	10.8	18.8	26.5	35.1	29.9	18.4	13.2	14.1	14.4	10.6	8.3	208.6
Bansur	7.9	10.7	18.7	26.7	35.1	31.3	20.4	16.3	16.8	15.8	10.6	7.9	218.2
Banswara	10.2	11.2	17.8	25.6	37.6	34.4	21.6	13.2	13.6	14.0	12.3	10.9	222.4
Bap	9.2	11.7	20.5	28.8	36.2	32.5	25.3	21.0	20.0	18.1	12.1	8.7	244.0
Baran	8.6	10.9	19.5	27.9	37.1	31.3	18.5	12.4	13.8	14.5	10.9	8.5	213.7
Bargaon	8.1	10.6	18.9	27.6	34.9	27.8	16.4	12.2	13.2	13.3	9.6	7.6	200.3
Bari	8.5	11.1	18.9	26.9	35.6	31.3	19.6	14.7	15.6	15.2	10.7	8.2	216.2
Bari Sadri	8.8	10.8	18.4	26.3	35.2	29.8	18.2	12.6	13.4	13.7	10.6	8.6	206.4
Barmer	10.7	12.1	17.5	22.7	28.3	26.1	22.9	17.9	19.0	19.5	14.8	11.5	222.8
Baseri	8.5	11.2	18.9	26.9	35.7	31.4	19.6	14.7	15.6	15.3	10.7	8.2	216.7
Bassi	8.3	11.6	19.6	27.3	36.5	33.7	20.1	15.4	17.3	16.8	11.5	8.8	226.9
Bawari	10.4	12.9	22.2	30.4	38.6	33.9	23.9	18.5	17.8	17.5	12.5	9.7	248.2
Bayana	8.3	11.1	18.9	26.9	35.6	31.5	19.8	15.1	15.9	15.4	10.8	8.2	217.4
Baytoo	10.5	12.1	18.5	24.5	30.7	27.8	23.2	18.3	18.8	19.0	14.1	10.9	228.3
Begun	8.7	11.0	18.7	26.2	34.7	29.3	17.0	11.6	12.9	13.9	10.8	8.5	203.3
Behror	7.6	10.4	18.4	26.5	34.7	30.7	20.5	16.7	16.9	15.6	10.4	7.7	216.0
Bhadesar	8.5	10.7	18.5	26.3	34.8	29.1	17.6	12.5	13.4	13.7	10.3	8.2	203.8
Bhadra	6.8	9.3	17.1	25.6	32.7	28.7	21.4	19.0	17.5	15.1	9.5	6.6	209.4
Bhainsrorgarh	9.0	11.4	18.5	25.3	33.3	28.0	15.2	10.1	11.8	13.4	10.9	8.7	195.5
Bhim	8.3	10.6	18.5	25.9	34.3	29.1	18.7	14.1	14.3	14.2	10.2	8.0	206.2
Bhindar	8.4	10.6	18.7	27.1	35.1	28.6	17.2	12.5	13.3	13.5	10.0	8.0	203.0
Bhinmal	8.8	10.6	17.4	23.8	31.2	27.0	19.9	15.4	15.6	15.5	11.2	8.7	205.0
Bhopalgarh	9.9	12.4	21.5	29.6	37.7	33.0	23.2	18.0	17.5	17.0	12.1	9.4	241.4
Bhopalsagar	8.3	10.5	18.4	26.5	34.6	28.5	17.2	12.6	13.3	13.5	9.9	7.9	201.2

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Bichhiwara	8.8	10.6	18.2	26.1	35.3	30.1	18.8	13.1	13.6	13.8	10.7	8.8	207.8
Bikaner	7.7	10.3	18.9	27.4	35.4	32.8	26.1	22.4	21.1	17.7	11.1	7.3	238.4
Bilara	9.8	12.2	21.2	29.2	37.4	32.5	22.5	17.3	16.9	16.6	11.9	9.2	236.7
Binay	8.4	11.0	19.1	26.9	35.5	30.8	19.3	14.2	15.1	15.1	10.9	8.4	214.5
Bonli	8.3	11.2	19.3	27.3	36.3	32.4	19.6	14.6	16.0	15.8	11.1	8.5	220.4
Buhana	7.3	9.8	18.0	26.4	33.8	29.7	21.0	18.1	17.5	15.5	10.0	7.2	214.3
Bundi	8.6	10.9	19.6	27.9	37.1	31.2	18.2	11.9	13.4	14.3	10.9	8.4	212.6
Chaksu	8.3	11.6	19.6	27.3	36.5	33.6	20.1	15.3	17.3	16.8	11.5	8.8	226.7
Chhabra	8.6	10.9	19.1	27.1	36.2	30.8	18.4	12.6	13.8	14.4	10.9	8.5	211.5
Chhipabarod	8.7	10.9	19.2	27.2	36.2	30.7	18.2	12.3	13.6	14.3	10.9	8.5	210.8
Chhoti Sadri	8.9	10.9	18.4	26.2	35.3	30.2	18.3	12.5	13.4	13.8	10.8	8.8	207.4
Chhoti Sarvan	10.1	11.2	17.8	25.6	37.5	34.1	21.4	13.2	13.6	14.0	12.2	10.8	221.5
Chirawa	7.0	9.5	17.7	26.3	33.2	28.9	21.1	18.6	17.7	15.3	9.7	6.8	211.9
Chitalwana	9.5	11.2	17.9	24.3	31.4	27.6	21.2	16.4	16.8	16.8	12.3	9.5	215.1
Chittaurgarh	8.7	10.9	18.6	26.2	34.8	29.3	17.5	12.3	13.3	13.8	10.5	8.4	204.3
Chohtan	10.2	11.8	18.1	24.1	30.4	27.3	22.5	17.6	18.3	18.4	13.7	10.6	222.9
Churu	6.7	9.1	17.2	26.0	32.3	27.7	21.1	19.3	17.9	15.1	9.3	6.4	208.1
Dag	8.9	11.0	18.7	26.3	35.5	30.4	18.1	12.2	13.3	14.1	11.0	8.8	208.4
Danta Ramgarh	7.8	10.7	18.7	26.8	35.0	31.3	20.6	16.7	17.2	16.0	10.7	7.9	219.3
Dausa	8.2	11.4	19.4	27.2	36.2	33.0	20.1	15.3	16.9	16.4	11.2	8.6	224.0
Deeg	8.0	10.8	18.7	26.7	35.3	31.2	20.0	15.6	16.2	15.4	10.6	8.0	216.7
Degana	8.4	11.0	19.5	27.5	35.6	31.3	21.7	17.3	17.2	16.2	11.1	8.3	225.1
Deogarh	8.2	10.4	18.1	25.5	33.8	28.4	18.1	13.6	13.8	13.8	9.9	7.7	201.2
Deoli	8.5	11.0	19.3	27.4	36.3	31.3	18.8	13.2	14.5	14.9	10.9	8.5	214.6
Desuri	7.0	9.0	16.3	22.9	31.3	25.7	16.4	12.6	12.4	12.1	8.3	6.5	180.8

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Dhariawad	9.3	10.9	18.2	26.0	36.2	31.6	19.5	12.9	13.5	13.9	11.2	9.5	212.8
Dhaulpur	8.5	11.1	18.8	26.8	35.5	31.2	19.7	14.9	15.6	15.2	10.7	8.1	215.9
Dhond	7.4	10.1	18.2	26.6	34.1	30.0	21.1	17.9	17.5	15.7	10.2	7.3	216.1
Dhorimanna	10.0	11.6	17.8	23.6	30.0	27.0	22.0	17.1	17.8	18.0	13.4	10.4	218.6
Didwana	7.7	10.4	18.6	26.7	34.5	30.5	21.4	17.8	17.4	15.9	10.5	7.6	219.1
Dudu	8.2	11.3	19.3	27.2	36.1	32.6	20.1	15.5	16.8	16.3	11.1	8.5	223.0
Dungargarh	7.5	10.0	18.4	26.8	34.4	31.0	23.8	20.6	19.4	16.6	10.5	7.2	226.2
Dungarpur	9.0	10.8	18.2	26.1	35.7	30.8	19.2	13.0	13.6	13.8	10.9	9.1	210.2
Dungla	8.5	10.7	18.5	26.5	34.9	29.1	17.6	12.5	13.3	13.6	10.2	8.2	203.8
Fatehpur	6.8	9.3	17.3	26.1	32.6	28.1	21.1	19.2	17.9	15.2	9.4	6.5	209.5
Ganganagar	4.7	6.9	12.9	20.5	28.4	26.2	20.7	19.4	15.7	12.8	7.3	4.8	180.3
Gangapur	8.3	11.2	19.2	27.1	36.0	32.0	19.7	14.7	16.0	15.7	11.0	8.4	219.2
Gangrar	8.6	10.8	18.6	26.3	34.8	29.3	17.7	12.5	13.4	13.9	10.5	8.3	204.6
Garhi	9.9	11.1	17.9	25.7	37.2	33.6	21.1	13.2	13.6	14.0	12.0	10.6	220.0
Ghadsana	7.2	9.6	17.6	25.8	33.6	30.5	23.7	20.5	18.8	16.2	10.2	7.0	220.8
Ghatol	10.0	11.1	17.9	25.7	37.3	33.8	21.2	13.2	13.6	14.0	12.0	10.6	220.3
Girwa	8.3	10.7	19.0	27.7	35.2	28.2	16.7	12.3	13.3	13.5	9.8	7.8	202.5
Gogunda	7.3	9.5	17.1	24.6	32.5	26.1	15.9	12.1	12.4	12.3	8.6	6.7	184.9
Govindgarh	8.1	11.3	19.3	27.1	36.0	32.9	20.3	15.8	17.2	16.5	11.2	8.5	224.2
Hanumangarh	5.4	7.6	14.2	21.9	29.7	27.1	21.2	19.4	16.3	13.6	8.0	5.4	189.8
Hindaun	8.3	11.1	19.0	27.0	35.8	31.7	19.7	14.9	16.0	15.5	10.9	8.3	218.3
Hindoli	8.6	10.9	19.4	27.6	36.7	31.0	18.3	12.3	13.7	14.4	10.9	8.5	212.3
Hurda	8.5	10.9	18.9	26.6	35.1	30.1	18.9	13.8	14.6	14.7	10.7	8.3	211.0
Itawa	8.5	10.9	19.5	27.8	37.0	31.5	18.8	12.8	14.2	14.7	10.9	8.5	215.3
Jahazpur	8.6	11.0	19.2	27.1	35.9	30.5	18.1	12.5	13.8	14.4	10.8	8.5	210.3

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Jaisalmer	10.7	13.4	23.5	33.1	39.5	35.4	30.2	25.7	23.9	21.1	13.8	9.9	280.1
Jaitaran	8.8	11.3	19.8	27.6	35.8	31.1	20.9	16.0	16.0	15.7	11.2	8.6	222.9
Jalor	6.9	8.8	15.7	21.8	30.2	25.0	16.7	13.0	12.6	12.2	8.3	6.4	177.6
Jamwa Ramgarh	8.2	11.5	19.5	27.2	36.3	33.4	20.2	15.5	17.3	16.7	11.4	8.7	225.7
Jaswantpura	7.5	9.3	16.3	22.6	30.7	25.7	17.5	13.6	13.4	13.1	9.1	7.1	185.9
Jawaja	8.5	10.9	18.9	26.6	34.9	30.0	19.5	14.6	14.9	14.8	10.6	8.3	212.5
Jayal	8.1	10.7	19.1	27.3	35.2	31.3	22.6	18.6	18.0	16.4	10.9	7.9	226.0
Jhadol	8.1	10.4	18.4	26.6	34.4	27.9	16.9	12.5	13.2	13.3	9.7	7.6	199.0
Jhalrapatan	8.8	11.0	19.1	26.8	35.7	30.2	17.5	11.7	13.1	14.1	10.9	8.6	207.4
Jhotwara	8.3	11.6	19.6	27.3	36.6	33.8	20.2	15.4	17.5	16.9	11.5	8.8	227.6
Jhunjhunun	6.9	9.4	17.5	26.2	32.9	28.5	21.1	18.9	17.8	15.2	9.6	6.7	210.7
Kaman	7.9	10.7	18.6	26.6	35.1	31.1	20.2	15.9	16.3	15.4	10.5	7.9	216.3
Kapasan	8.4	10.6	18.4	26.3	34.6	28.8	17.5	12.6	13.4	13.6	10.1	8.0	202.5
Karanpur	5.0	7.2	13.4	21.1	29.0	26.6	21.0	19.4	15.9	13.1	7.6	5.1	184.4
Karauli	8.5	11.2	19.0	27.0	35.9	31.7	19.6	14.7	15.7	15.4	10.8	8.3	217.8
Kathumar	8.1	10.9	18.8	26.8	35.5	31.6	20.0	15.5	16.3	15.6	10.8	8.1	218.2
Kekri	8.5	11.0	19.1	27.0	35.8	30.9	18.8	13.5	14.6	14.9	10.9	8.4	213.6
Keshorai Patan	8.5	10.8	19.8	28.4	37.8	32.0	19.0	12.6	14.0	14.7	10.9	8.4	216.8
Khairabad	8.8	11.1	19.1	26.9	35.6	30.0	17.1	11.3	12.8	14.0	10.9	8.5	206.1
Khajuwala	7.8	10.3	18.8	27.1	34.9	31.8	25.0	21.3	20.0	17.2	11.0	7.5	232.7
Khamnor	7.9	10.2	18.1	26.2	34.0	27.5	16.6	12.4	13.0	13.1	9.4	7.4	195.8
Khandar	8.5	11.0	19.3	27.4	36.4	31.6	19.1	13.7	15.0	15.1	10.9	8.4	216.5
Khandela	7.7	10.6	18.6	26.7	34.9	31.2	20.6	16.8	17.2	15.9	10.6	7.8	218.5
Khanpur	8.7	11.0	19.3	27.3	36.4	30.7	18.0	12.0	13.4	14.3	10.9	8.5	210.5
Kherwara	8.4	10.5	18.3	26.3	34.7	28.9	17.9	12.9	13.5	13.6	10.1	8.2	203.1

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Khetri	7.4	10.0	18.2	26.5	34.1	30.0	21.0	17.8	17.4	15.6	10.1	7.3	215.4
Kishanganj	8.6	10.9	19.4	27.5	36.6	31.1	18.6	12.6	13.9	14.5	10.9	8.5	213.2
Kishangarh	8.2	11.0	19.1	27.0	35.6	31.6	20.2	15.6	16.4	15.8	11.0	8.3	220.0
Kishangarh Bas	7.9	10.7	18.6	26.6	35.0	31.1	20.3	16.2	16.6	15.6	10.6	7.9	217.1
Kolayat	8.3	10.8	19.5	27.8	35.5	32.4	25.4	21.5	20.3	17.7	11.5	7.9	238.7
Kotkasim	7.8	10.5	18.4	26.5	34.7	30.8	20.4	16.5	16.7	15.5	10.4	7.7	215.8
Kotputli	7.8	10.6	18.6	26.7	35.0	31.3	20.4	16.5	17.0	15.8	10.6	7.9	218.2
Kotra	7.5	9.7	17.2	24.7	32.8	26.6	16.4	12.4	12.7	12.6	8.9	7.0	188.4
Kotri	8.6	10.9	18.9	26.6	35.2	29.9	17.8	12.4	13.5	14.2	10.7	8.4	207.2
Kuchaman City	8.0	10.8	18.8	26.8	35.1	31.4	20.6	16.5	17.0	16.0	10.8	8.0	219.9
Kumbhalgarh	7.4	9.5	17.0	24.1	32.4	26.5	16.6	12.6	12.7	12.6	8.8	6.9	187.1
Kumher	8.1	10.9	18.7	26.7	35.3	31.3	20.0	15.4	16.1	15.4	10.7	8.1	216.7
Kushalgarh	9.9	11.1	17.9	25.7	37.2	33.7	21.2	13.2	13.7	14.0	12.0	10.6	220.3
Lachhmangarh(Alwar)	8.06	10.9	18.8	26.8	35.5	31.6	20.09	15.6	16.5	15.7	10.8	8.1	218.6
Lachhmangarh (Sikar)	7.4	9.9	18.1	26.6	33.9	29.8	21.5	18.5	17.8	15.7	10.1	7.2	216.5
Ladnu	7.5	10.1	18.5	26.9	34.5	30.4	22.1	18.7	18.0	15.9	10.3	7.4	220.4
Ladpur	8.6	10.8	19.9	28.6	38.0	31.8	18.6	12.0	13.5	14.4	10.9	8.4	215.5
Lalsot	8.3	11.4	19.4	27.2	36.3	32.9	19.9	15.1	16.7	16.3	11.2	8.6	223.3
Lasadiya	8.7	10.7	18.5	26.5	35.4	29.8	18.2	12.7	13.4	13.7	10.5	8.6	206.7
Luni	10.6	13.1	22.5	30.6	38.9	34.0	23.7	18.1	17.3	17.4	12.6	10.0	248.8
Lunkaransar	7.3	9.7	17.9	26.2	33.9	30.7	23.9	20.7	19.2	16.4	10.3	7.0	223.2
Mahuwa	8.2	11.1	19.0	26.9	35.7	31.9	19.9	15.3	16.3	15.7	10.9	8.3	219.1
Makrana	8.1	10.8	18.8	26.8	34.9	30.8	21.0	17.0	17.0	15.9	10.7	7.9	219.7
Malpura	8.3	11.2	19.3	27.2	36.1	32.2	19.7	14.8	16.2	15.9	11.2	8.6	220.6
Mandal	8.4	10.7	18.5	26.1	34.5	29.2	18.3	13.4	14.0	14.1	10.3	8.1	205.7

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mandalgarh	8.8	11.1	18.9	26.5	35.1	29.6	17.0	11.5	12.9	14.0	10.8	8.5	204.4
Mandawar	7.8	10.5	18.5	26.6	34.8	30.9	20.4	16.4	16.7	15.6	10.5	7.8	216.5
Mandor	11.0	13.6	23.4	31.7	40.0	35.1	24.4	18.5	17.7	17.8	13.0	10.3	256.6
Manohar Thana	8.7	10.9	19.0	26.9	35.9	30.6	18.2	12.4	13.6	14.3	10.9	8.6	210.2
Marwar Junction	8.3	10.5	18.4	25.7	34.1	28.9	19.0	14.4	14.3	14.2	10.1	7.9	205.8
Masooda	8.4	10.9	19.0	26.8	35.3	30.5	19.5	14.5	15.1	15.0	10.8	8.4	214.1
Mavli	8.2	10.5	18.7	27.2	34.8	28.1	16.8	12.4	13.3	13.4	9.8	7.7	200.9
Merta	9.0	11.5	20.3	28.3	36.3	31.8	22.2	17.5	17.2	16.5	11.5	8.7	230.7
Mundwa	9.1	11.7	20.4	28.5	36.5	32.2	23.3	18.6	18.1	16.9	11.7	8.7	235.7
Nadbai	8.1	10.9	18.8	26.8	35.5	31.5	19.9	15.4	16.2	15.5	10.7	8.1	217.4
Nadoti	8.2	11.2	19.2	27.1	36.0	32.3	19.8	15.0	16.3	15.9	11.0	8.4	220.5
Nagaur	8.6	11.1	19.6	27.9	35.7	32.0	24.0	19.9	19.0	17.0	11.3	8.1	234.2
Nainwa	8.5	10.9	19.6	27.9	37.1	31.6	18.8	12.8	14.2	14.7	10.9	8.4	215.5
Nawalgarh	7.1	9.7	17.8	26.4	33.5	29.2	21.1	18.5	17.7	15.4	9.8	7.0	213.1
Neem Ka Thana	7.7	10.5	18.5	26.6	34.8	31.0	20.5	16.8	17.1	15.8	10.5	7.7	217.4
Nimbahera	8.7	10.9	18.5	26.2	34.9	29.5	17.6	12.2	13.2	13.8	10.6	8.5	204.8
Nimrana	7.6	10.2	18.3	26.4	34.5	30.5	20.5	16.8	16.9	15.5	10.3	7.6	215.1
Niwai	8.3	11.4	19.4	27.3	36.4	33.0	19.9	14.9	16.6	16.3	11.3	8.6	223.5
Nohar	6.7	9.1	16.7	25.0	32.3	28.6	21.7	19.3	17.6	15.0	9.4	6.5	207.7
Nokha	8.0	10.6	19.2	27.6	35.5	32.4	25.2	21.3	20.2	17.4	11.2	7.6	236.1
Osian	10.2	12.7	21.8	30.0	38.0	33.4	24.1	18.9	18.1	17.6	12.4	9.6	246.7
Padampur	5.0	7.2	13.4	21.1	29.0	26.6	21.0	19.4	15.9	13.1	7.6	5.1	184.5
Pahari	8.0	10.8	18.7	26.7	35.2	31.3	20.1	15.8	16.4	15.5	10.6	8.0	217.1
Pali	8.3	10.5	18.5	25.6	33.9	28.8	19.3	14.8	14.5	14.2	10.0	7.8	206.4
Parbatsar	8.2	10.9	19.0	26.9	35.2	31.1	20.6	16.2	16.6	15.8	10.9	8.2	219.7

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Peepalkhoont	9.9	11.1	17.9	25.7	37.2	33.6	21.0	13.1	13.6	14.0	12.0	10.5	219.6
Peesangan	8.4	11.0	19.2	27.0	35.4	30.9	20.1	15.2	15.7	15.4	10.9	8.4	217.7
Phagi	8.3	11.5	19.5	27.3	36.5	33.4	20.1	15.3	17.2	16.7	11.4	8.7	225.9
Phalodi	9.7	12.1	20.8	28.9	36.4	32.4	24.7	20.1	19.2	17.8	12.2	9.1	243.4
Pilibanga	5.4	7.6	14.3	22.1	29.8	27.2	21.3	19.5	16.4	13.6	8.1	5.5	190.8
Pindwara	6.5	8.4	15.3	21.6	30.0	24.4	15.4	11.9	11.7	11.3	7.6	5.9	170.0
Piprali	7.4	10.1	18.2	26.6	34.2	30.1	20.9	17.7	17.5	15.7	10.2	7.4	216.1
Pirawa	8.8	11.0	18.9	26.6	35.5	30.2	17.7	11.9	13.2	14.1	10.9	8.6	207.3
Pratapgarh	9.3	11.0	18.2	26.0	36.1	31.6	19.5	12.8	13.5	13.9	11.3	9.5	212.6
Railmagra	8.2	10.4	18.2	26.1	34.2	28.2	17.2	12.7	13.3	13.4	9.8	7.7	199.6
Raipur (Bhilwara)	8.3	10.6	18.5	26.3	34.8	30.3	20.005	15.4	15.6	15.08	10.6	8.2	213.7
Raipur (Pali)	8.8	11.2	19.6	27.3	35.6	30.7	20.5	15.6	15.6	15.4	11.0	8.5	219.8
Raisinghnagar	5.6	7.9	14.6	22.5	30.3	27.6	21.6	19.6	16.7	13.9	8.3	5.7	194.4
Rajakhera	8.5	11.1	18.7	26.7	35.4	31.0	19.7	14.9	15.6	15.1	10.6	8.1	215.5
Rajgarh (Alwar)	8.2	11.2	19.1	27.04	35.9	32.5	20.1	15.6	16.8	16.2	11.05	8.4	222.03
Rajgarh (Churu)	6.9	9.3	17.4	26.02	32.8	28.5	21.2	19.0	17.7	15.2	9.5	6.6	210.10
Rajsamand	7.9	10.1	17.9	25.5	33.6	27.6	17.0	12.7	13.2	13.1	9.4	7.4	195.4
Ramgarh	8.0	10.8	18.7	26.7	35.2	31.4	20.2	15.9	16.5	15.7	10.7	8.0	217.8
Rani	7.2	9.2	16.5	23.1	31.5	26.1	17.0	13.1	12.8	12.4	8.6	6.7	184.3
Raniwara	8.2	10.1	17.1	23.7	31.5	26.8	18.8	14.5	14.5	14.3	10.2	7.9	197.6
Rashmi	8.4	10.6	18.4	26.2	34.6	28.9	17.7	12.7	13.5	13.8	10.2	8.1	203.1
Ratangarh	6.9	9.4	17.5	26.2	32.9	28.5	21.5	19.3	18.0	15.4	9.6	6.6	212.0
Rawatsar	6.5	8.9	16.4	24.6	32.0	28.7	21.9	19.5	17.6	15.0	9.3	6.4	206.8
Reni	8.1	11.1	19.0	26.9	35.7	32.0	20.1	15.5	16.6	15.9	10.9	8.3	220.0
Reodar	7.5	9.4	16.5	23.1	31.3	26.0	17.3	13.3	13.2	12.9	9.0	7.0	186.3

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Rishabhdeo	8.5	10.6	18.4	26.6	35.0	29.0	17.7	12.7	13.4	13.6	10.2	8.2	203.9
Riyan	8.6	11.1	19.6	27.5	35.7	31.2	21.1	16.4	16.5	15.9	11.1	8.5	223.2
Rohat	9.6	11.9	20.5	28.1	36.4	31.4	21.6	16.6	16.0	15.9	11.4	9.0	228.4
Rupbas	8.2	10.9	18.8	26.8	35.5	31.3	19.8	15.1	15.9	15.3	10.7	8.1	216.5
Sadulshahar	4.8	6.9	13.1	20.7	28.6	26.3	20.8	19.4	15.7	12.9	7.4	4.9	181.4
Sagwara	9.5	11.0	18.1	25.9	36.5	32.4	20.3	13.1	13.6	13.9	11.5	9.9	215.8
Sahara	8.3	10.5	18.3	26.0	34.3	28.7	17.7	12.9	13.5	13.7	10.0	7.9	201.8
Sajjangarh	9.9	11.1	17.9	25.7	37.2	33.6	21.1	13.2	13.7	14.0	12.0	10.5	220.1
Salumbar	8.8	10.8	18.4	26.5	35.6	30.2	18.5	12.8	13.5	13.7	10.7	8.8	208.3
Sam	11.0	13.5	23.3	32.7	38.9	34.8	30.1	25.5	23.9	21.3	14.2	10.2	279.5
Sambhar	8.2	11.3	19.2	27.1	36.0	32.7	20.3	15.8	17.1	16.4	11.1	8.4	223.6
Sanchore	8.9	10.8	17.7	24.3	31.7	27.5	20.2	15.6	15.9	15.8	11.4	8.9	208.6
Sanganer	8.3	11.7	19.7	27.4	36.6	34.0	20.2	15.4	17.5	17.0	11.6	8.9	228.1
Sangariya	5.3	7.4	13.9	21.6	29.5	26.9	21.1	19.4	16.1	13.4	7.9	5.3	187.8
Sangod	8.6	10.9	19.6	28.0	37.2	31.3	18.3	12.0	13.5	14.4	10.9	8.5	213.2
Sankra	10.5	12.9	21.8	30.2	36.8	32.9	27.1	22.4	21.4	19.7	13.5	10.0	259.0
Sapotra	8.5	11.2	19.1	27.1	36.0	31.7	19.4	14.4	15.5	15.3	10.9	8.3	217.3
Sarada	8.5	10.7	18.7	27.0	35.2	28.9	17.5	12.6	13.4	13.6	10.1	8.1	204.2
Sardarshahar	6.9	9.4	17.4	26.0	32.9	28.9	21.9	19.5	18.1	15.5	9.7	6.7	213.0
Sawai Madhopur	8.4	11.1	19.3	27.4	36.4	31.9	19.3	14.0	15.3	15.4	11.0	8.5	218.0
Sayla	8.4	10.3	17.3	23.7	31.4	26.9	19.4	15.0	15.0	14.8	10.6	8.2	201.0
Sewar	8.1	10.9	18.7	26.7	35.4	31.2	19.9	15.3	16.0	15.4	10.7	8.1	216.4
Shahbad	8.6	10.9	19.2	27.3	36.3	31.0	18.7	13.0	14.2	14.7	10.9	8.5	213.3
Shahpura (Jaipur)	8.1	11.2	19.2	27.1	36.0	32.8	20.3	15.8	17.2	16.5	11.1	8.5	223.8
Shahpura (Bhilwara)	8.5	10.9	19.01	26.8	35.5	30.5	18.7	13.5	14.5	14.7	10.8	8.4	211.8

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Sheo	10.7	12.5	19.9	26.9	32.9	29.8	25.4	20.6	20.5	19.8	14.2	10.8	244.0
Sheoganj	5.6	7.3	13.6	19.0	27.7	22.2	14.1	11.2	10.5	9.9	6.3	4.8	152.2
Shergarh	10.2	12.5	21.0	28.8	36.2	32.0	24.2	19.2	18.6	18.0	12.7	9.7	243.1
Shrinagar	8.3	11.0	19.2	27.0	35.5	31.2	20.0	15.2	15.9	15.5	11.0	8.4	218.2
Sikrai	8.2	11.2	19.2	27.1	36.0	32.4	20.0	15.2	16.6	16.0	11.1	8.4	221.4
Simalwara	9.4	10.9	18.1	25.9	36.3	32.1	20.1	13.2	13.7	14.0	11.4	9.8	214.9
Sindhari	10.2	11.7	17.6	23.3	29.4	26.6	22.1	17.2	18.0	18.4	13.8	10.7	219.3
Sirohi	6.5	8.3	15.0	21.0	29.5	24.1	15.6	12.2	11.8	11.3	7.6	5.9	168.9
Siwana	9.1	11.1	18.8	25.7	33.5	28.9	20.7	16.0	15.8	15.7	11.2	8.7	215.2
Sojat	9.2	11.6	20.0	27.7	36.0	31.0	20.9	15.9	15.7	15.5	11.1	8.7	223.2
Srimadhopur	7.9	10.9	18.9	26.9	35.5	32.0	20.4	16.2	17.1	16.1	10.9	8.1	221.0
Sujangarh	7.4	10.0	18.3	26.8	34.2	30.3	22.6	19.5	18.5	16.1	10.3	7.2	221.2
Sultanpura	8.5	10.8	19.9	28.6	38.2	32.1	19.0	12.4	13.9	14.6	10.9	8.4	217.2
Sumerpur	6.0	7.8	14.3	20.0	28.6	23.2	14.8	11.7	11.0	10.5	6.8	5.3	159.9
Surajgarh	7.1	9.6	17.7	26.3	33.4	29.1	21.1	18.5	17.6	15.4	9.8	6.9	212.5
Suratgarh	6.2	8.5	15.7	23.7	31.3	28.4	22.0	19.7	17.3	14.6	8.9	6.1	202.2
Suwana	8.5	10.8	18.6	26.3	34.8	29.4	17.9	12.8	13.7	14.1	10.5	8.2	205.6
Talera	8.7	11.0	19.5	27.8	36.9	30.9	17.8	11.5	13.1	14.2	10.9	8.5	210.9
Taranagar	6.8	9.3	17.2	25.9	32.6	28.3	21.3	19.2	17.8	15.2	9.4	6.5	209.6
Thanagazi	8.1	11.1	19.1	27.0	35.7	32.3	20.2	15.8	16.9	16.2	11.0	8.3	221.7
Tibi	5.8	8.1	15.0	23.0	30.6	27.7	21.4	19.3	16.7	14.1	8.5	5.8	196.0
Tijara	7.8	10.5	18.4	26.5	34.8	30.8	20.4	16.4	16.6	15.4	10.4	7.7	215.6
Todabhim	8.2	11.1	19.1	27.0	35.9	32.0	19.9	15.1	16.3	15.8	10.9	8.3	219.5
Todaraisingh	8.4	11.1	19.3	27.2	36.1	31.6	19.3	14.0	15.3	15.4	11.0	8.5	217.2
Tonk	8.4	11.2	19.4	27.3	36.3	32.3	19.5	14.4	15.9	15.8	11.2	8.6	220.2

Block	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Udaipurwati	7.3	10.0	18.1	26.5	34.0	29.8	21.0	18.0	17.5	15.6	10.1	7.2	215.1
Umren	8.0	10.9	18.8	26.8	35.4	31.7	20.2	15.9	16.7	15.8	10.8	8.1	219.3
Uniara	8.5	11.0	19.4	27.5	36.6	31.7	19.1	13.5	14.9	15.2	11.0	8.5	216.9
Viratnagar	8.0	11.0	19.0	26.9	35.6	32.1	20.3	16.0	17.0	16.1	10.9	8.2	221.2
Weir	8.2	11.0	18.9	26.9	35.6	31.6	19.9	15.3	16.2	15.6	10.8	8.2	218.1

Source: IMD monthly dataset (1990-2009)

Appendix 12

Sample Water Balance of Sub-Sub-Basin Gomti of Som Sub Basin of Mahi Basin Using SWAT Model

Evapotranspiration is not measured directly but rather simulated using the SWAT model, which simulates actual evapotranspiration on a continuous basis. Once the model is validated, this output is the best way to get the actual ET assessment for an area. SWAT uses Penmen Monteith Method to evaluate evapotranspiration over an area using daily weather parameters.

Monthly Evapotranspiration along with other water balance components for a Sub Sub basin of Mahi catchment is shown in the following Table.

Water Balance Components Using SWAT Simulation

Sub Basin	Year	Mon	Area, km^2	Precip., mm	Snow Melt, mm	PET, mm	ET, mm	SW, mm	PERC, mm	SURQ, mm	GW_Q, mm	WYLD, mm
4	2005	Jan	391.35	0.0	0.0	97.383	3.882	18.374	3.107	0.000	1.448	1.486
4	2005	Feb	391.35	0.0	0.0	120.999	5.355	17.169	6.001	0.000	2.887	2.915
4	2005	Mar	391.35	0.0	0.0	206.035	6.265	12.387	0.000	0.000	2.122	2.144
4	2005	Apr	391.35	22.9	0.0	193.420	1.861	21.190	11.380	0.646	0.002	0.681
4	2005	May	391.35	16.1	0.0	275.474	16.639	12.031	8.318	0.163	0.000	0.376
4	2005	Jun	391.35	41.5	0.0	234.846	8.082	23.636	21.482	0.040	0.000	0.185
4	2005	Jul	391.35	252.0	0.0	124.002	29.515	49.023	96.384	98.923	0.000	99.634
4	2005	Aug	391.35	168.2	0.0	150.183	35.119	31.029	83.749	66.169	33.436	100.728
4	2005	Sep	391.35	272.3	0.0	102.577	34.025	44.851	145.513	76.388	57.085	134.672
4	2005	Oct	391.35	0.0	0.0	143.250	19.020	26.099	0.000	0.000	73.573	73.914
4	2005	Nov	391.35	0.0	0.0	110.117	9.557	22.777	1.209	0.000	31.483	31.574
4	2005	Dec	391.35	0.0	0.0	92.925	4.702	20.642	3.393	0.000	4.959	5.023

Where:

Year:	Simulated Year
Mon:	Month
Area, km^2:	Area of Sub Sub basin in km^2
Precip.:	Rain (mm)
PET:	Potential evapotranspiration
ET:	Actual evapotranspiration
SW:	Soil Moisture (End of the Simulation status)
PERC:	Percolation (Shallow+Deep)
SURQ:	Direct Surface Runoff
GW_Q:	Baseflow
WYLD:	Total Water yield (SURQ+GW_Q+Lateral Flow)

Appendix 13

Gauge and Discharge Sites – Flow Duration Curves

Stream discharge analysis was performed for selected sites within various basins as per data availability and their location in the basin. The stream gauge data validation is still under process and after refinement and validation it will be used as an input for hydrological modelling.

Stream gauge discharge data for selected sites were analysed and Discharge-Time curves were plotted along with Flow duration curves.

Frequency analysis takes a different approach in characterising baseflow by deriving the relationship between the magnitude and frequency of streamflow discharges from the hydrographic record. In its most common application, a flow duration curve (FDC) is generated. Instead of plotting as a time series, a flow duration curve shows the percentage of time that a given flow rate is equalled or exceeded (probability of occurrence). The FDC is constructed from flow data of fixed time period (e.g. daily, monthly, annually) by:

1. sorting the flow data in order of decreasing flow;
2. assigning a unique ranking number m to each flow, starting with 1 for the maximum flow to n for the minimum flow, where n is the number of flow measurements.
3. the probability p that a given flow will be equalled or exceeded is defined by: p = 100 x m/(n+1)
4. the flow-probability relationship is typically presented as a log-normal plot (fetter, 1994).

The FDC provides information on the baseflow component of stream flow. The median flow (Q50) is the discharge which is equalled or exceeded 50% of the time. The part of the curve with flows below the median flow represents low-flow conditions. Baseflow is interpreted to be significant if this part of the curve has a low slope, as this reflects continuous discharge to the stream. A steep slope for these low-flows suggests relatively small contributions from natural storages like groundwater. These streams may cease to flow for relatively long periods. In this way, the shape of the FDC can indicate the hydrogeological characteristics of a catchment (Smakhtin, 2001).

Flow duration curves for selected sites in various agroclimatic zones are presented below.

Figure 1 Flow Duration Curve for Gandhav Site in ACZ Ia

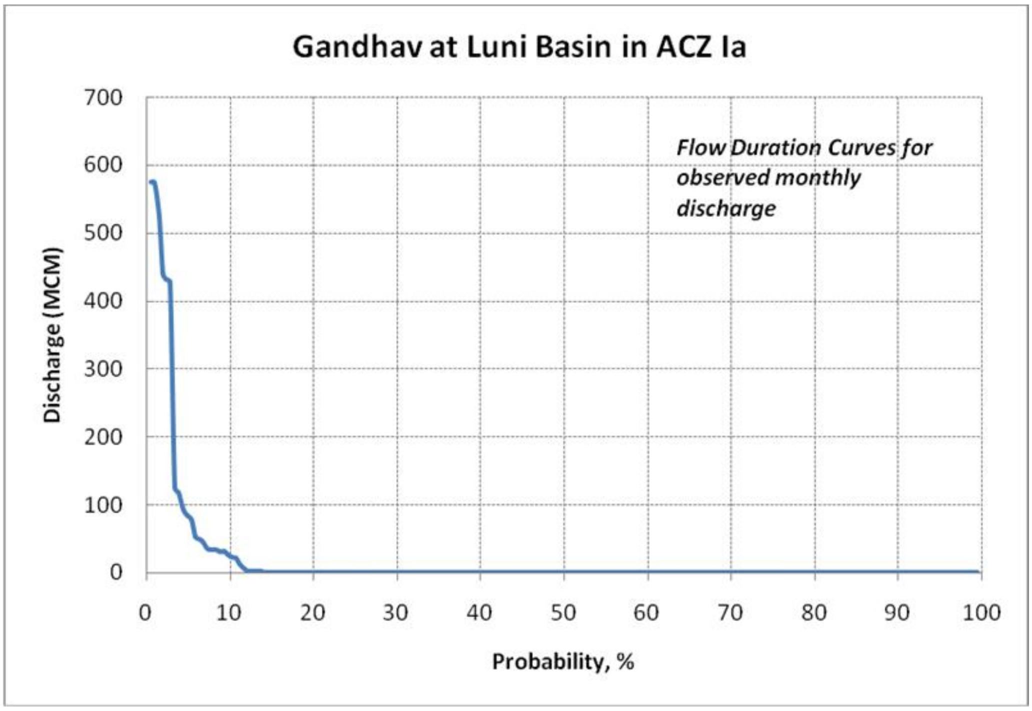


Figure 2 Flow Duration Curve for Ringus Site in ACZ IIa

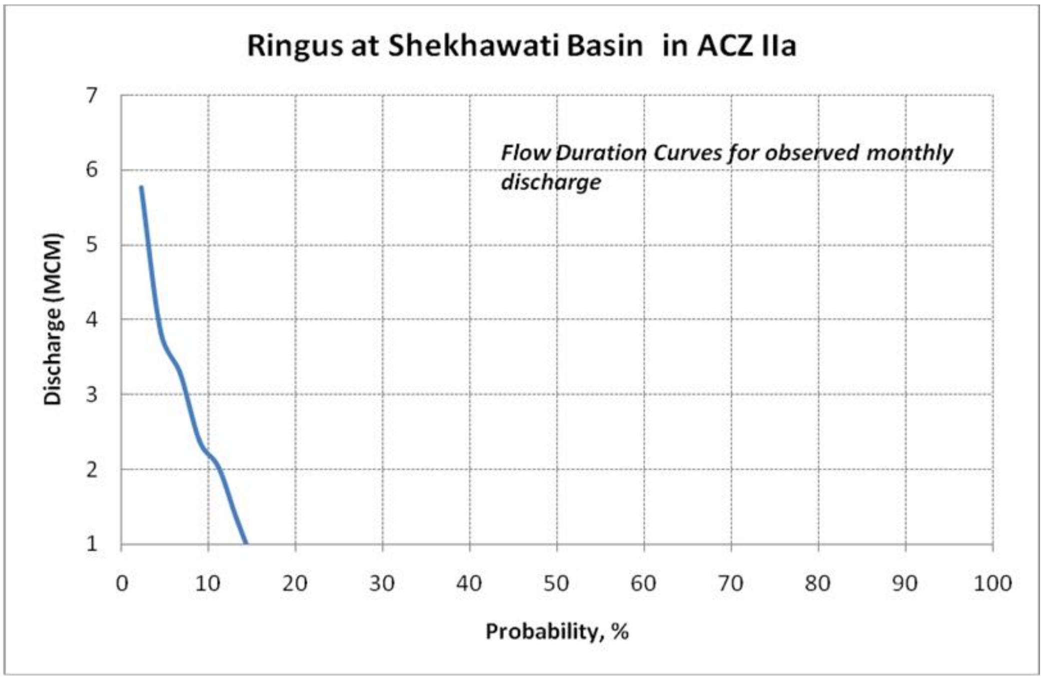


Figure 3 Flow Duration Curve for Berami Site in ACZ IIb

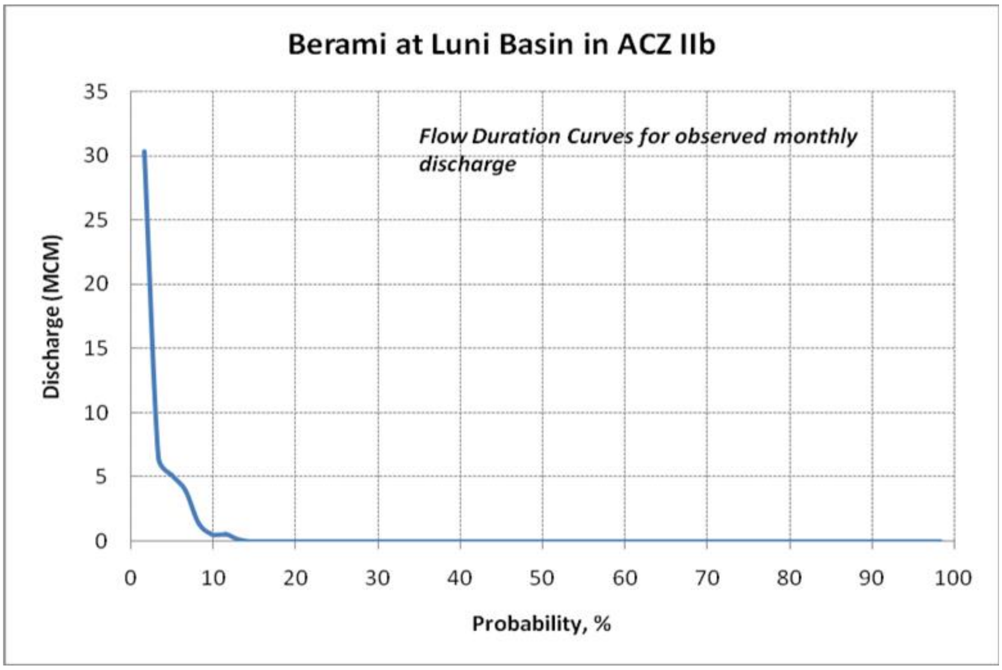


Figure 4 Flow Duration Curve for Negaria Site in ACZ IIIa

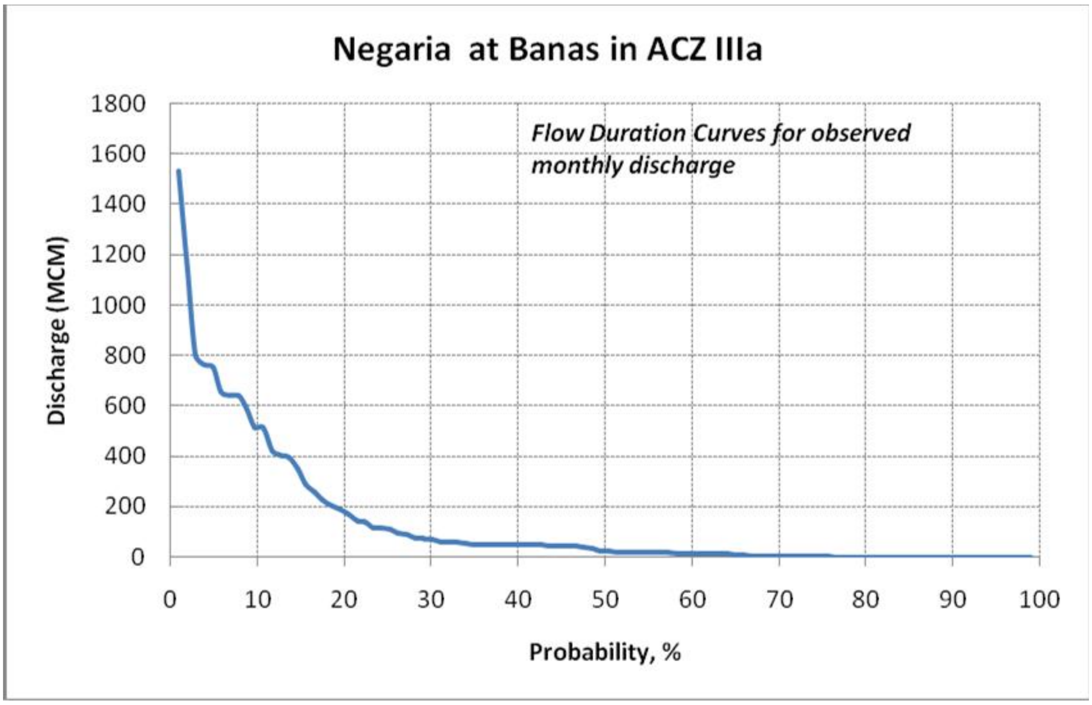


Figure 5 Flow Duration Curve for Sri Mahabirji Site in ACZ IIIb

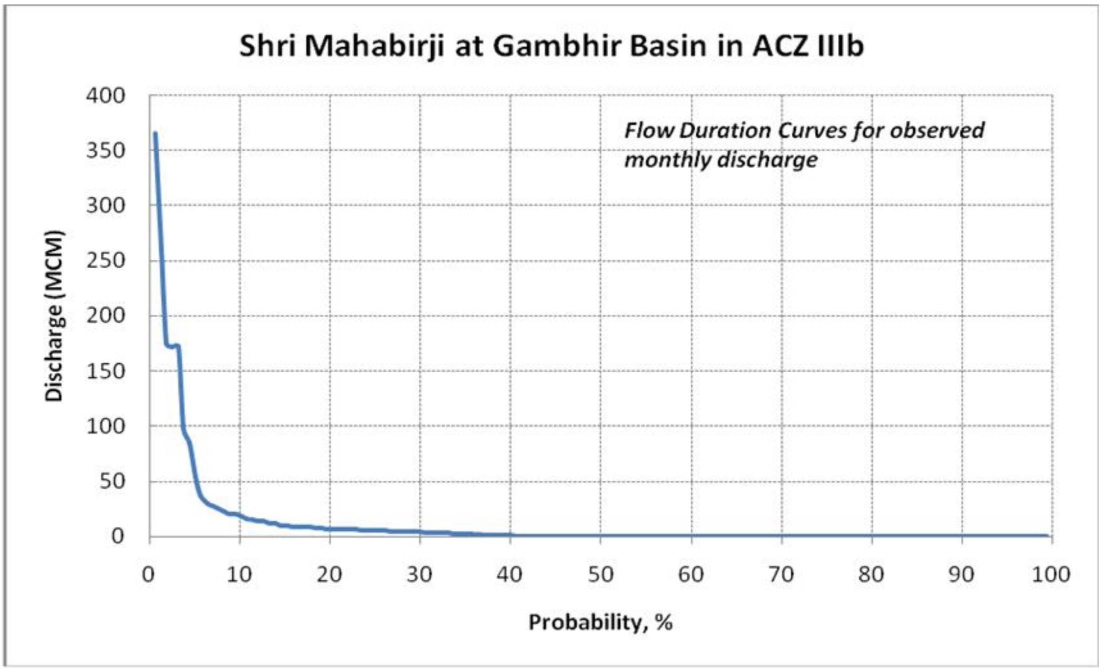


Figure 6 Flow Duration Curve for Pipli Site in ACZ IVa

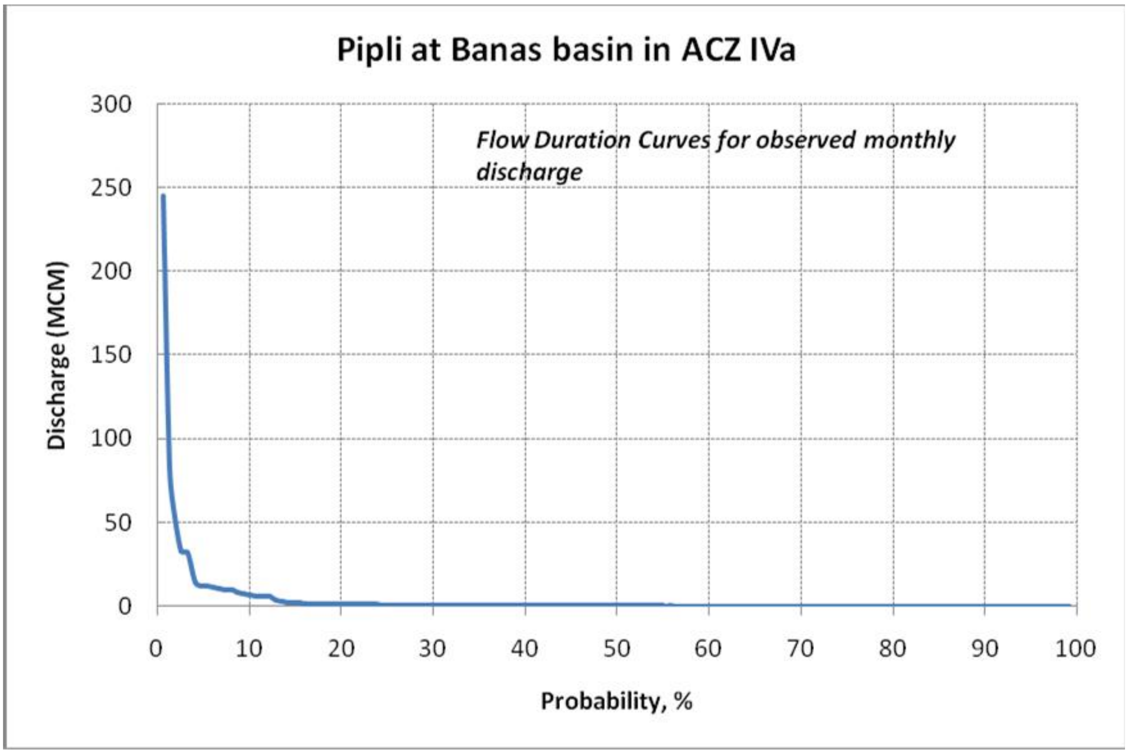


Figure 7 Flow Duration Curve for Padardibadi Site in ACZ IVb

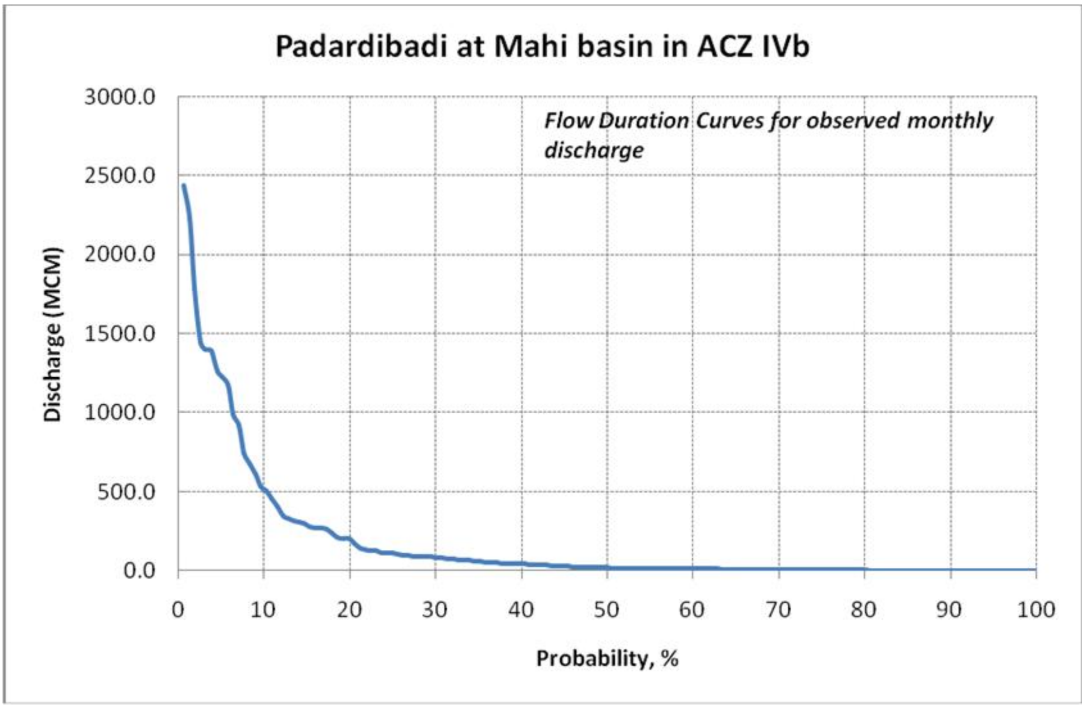
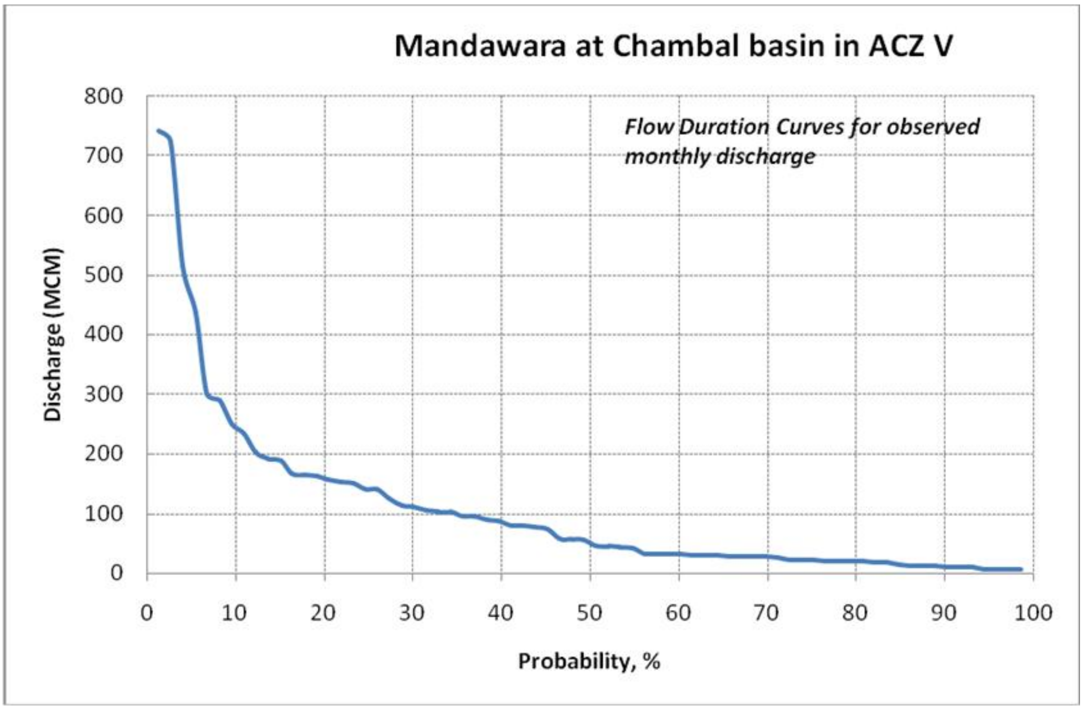


Figure 8 Flow Duration Curve for Mandawara site in ACZ V



The surface water yields of the above-mentioned sites at various dependability levels are presented in Table 1.

Table 1: Discharge at Various Dependability Levels, Mm^3/yr

Site \ Dependability Level	25%	50%	75%	90%
Mandawara	141.1	51.2	21.9	10.7
Mahavirji	5.4	0.0	0.0	0.0
Gandhav	0.0	0.0	0.0	0.0
Ringus	0.0	0.0	0.0	0.0
Padardibadi	108.2	19.2	6.1	0.0
Pipli	0.8	0.1	0.0	0.0
Negaria	113.0	23.3	0.9	0.0
Berami	0.0	0.0	0.0	0.0

See supporting Tables 2 and 3 below.

Table 2 Flow Data at Various Probability Levels

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
1.4	740.9	0.6	365.8	0.5	574.9	2.2	5.8
2.7	723.0	1.3	259.5	1.0	574.0	4.4	3.8
4.1	514.6	1.9	175.4	1.5	525.5	6.7	3.3
5.5	436.0	2.5	172.1	2.0	440.8	8.9	2.4
6.8	302.0	3.2	171.7	2.4	432.4	11.1	2.0
8.2	289.8	3.8	98.9	2.9	427.9	13.3	1.3
9.6	250.5	4.5	85.3	3.4	126.0	15.6	0.7
11.0	234.0	5.1	54.0	3.9	118.1	17.8	0.6
12.3	201.8	5.7	37.4	4.4	93.2	20.0	0.3
13.7	191.8	6.4	29.8	4.9	84.3	22.2	0.1
15.1	189.0	7.0	27.1	5.4	77.2	24.4	0.1
16.4	166.6	7.6	25.5	5.9	53.5	26.7	0.1
17.8	164.2	8.3	22.1	6.3	49.0	28.9	0.0
19.2	162.1	8.9	20.6	6.8	46.3	31.1	0.0
20.5	157.0	9.6	19.6	7.3	35.9	33.3	0.0
21.9	153.8	10.2	18.1	7.8	33.8	35.6	0.0
23.3	151.8	10.8	15.5	8.3	33.7	37.8	0.0
24.7	141.1	11.5	15.2	8.8	31.3	40.0	0.0
26.0	140.8	12.1	13.8	9.3	31.3	42.2	0.0
27.4	124.4	12.7	13.5	9.8	27.2	44.4	0.0
28.8	114.1	13.4	11.8	10.2	22.8	46.7	0.0
30.1	112.2	14.0	11.3	10.7	20.9	48.9	0.0
31.5	105.8	14.6	9.8	11.2	12.8	51.1	0.0
32.9	102.8	15.3	9.6	11.7	6.5	53.3	0.0
34.2	102.6	15.9	8.6	12.2	2.9	55.6	0.0
35.6	95.7	16.6	8.3	12.7	1.9	57.8	0.0
37.0	95.3	17.2	8.3	13.2	1.5	60.0	0.0
38.4	88.7	17.8	8.1	13.7	1.4	62.2	0.0
39.7	86.6	18.5	7.8	14.1	1.2	64.4	0.0
41.1	80.0	19.1	7.1	14.6	1.0	66.7	0.0
42.5	79.0	19.7	6.8	15.1	0.8	68.9	0.0
43.8	77.3	20.4	6.8	15.6	0.3	71.1	0.0
45.2	74.3	21.0	6.6	16.1	0.2	73.3	0.0
46.6	57.3	21.7	6.5	16.6	0.0	75.6	0.0
47.9	57.1	22.3	6.3	17.1	0.0	77.8	0.0
49.3	56.2	22.9	6.0	17.6	0.0	80.0	0.0
50.7	46.3	23.6	5.6	18.0	0.0	82.2	0.0
52.1	45.4	24.2	5.4	18.5	0.0	84.4	0.0

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
53.4	43.4	24.8	5.4	19.0	0.0	86.7	0.0
54.8	42.4	25.5	5.4	19.5	0.0	88.9	0.0
56.2	32.8	26.1	5.2	20.0	0.0	91.1	0.0
57.5	32.6	26.8	4.5	20.5	0.0	93.3	0.0
58.9	31.9	27.4	4.4	21.0	0.0	95.6	0.0
60.3	31.2	28.0	4.1	21.5	0.0	97.8	0.0
61.6	30.3	28.7	4.0	22.0	0.0		
63.0	29.3	29.3	3.9	22.4	0.0		
64.4	29.3	29.9	3.9	22.9	0.0		
65.8	29.0	30.6	3.5	23.4	0.0		
67.1	28.6	31.2	3.5	23.9	0.0		
68.5	28.2	31.8	3.3	24.4	0.0		
69.9	28.2	32.5	3.3	24.9	0.0		
71.2	25.6	33.1	2.9	25.4	0.0		
72.6	22.6	33.8	2.5	25.9	0.0		
74.0	22.0	34.4	2.4	26.3	0.0		
75.3	21.9	35.0	2.0	26.8	0.0		
76.7	21.1	35.7	1.7	27.3	0.0		
78.1	20.8	36.3	1.6	27.8	0.0		
79.5	20.4	36.9	1.6	28.3	0.0		
80.8	20.1	37.6	1.4	28.8	0.0		
82.2	18.8	38.2	1.3	29.3	0.0		
83.6	17.6	38.9	1.1	29.8	0.0		
84.9	14.0	39.5	1.0	30.2	0.0		
86.3	12.2	40.1	0.7	30.7	0.0		
87.7	11.9	40.8	0.3	31.2	0.0		
89.0	11.6	41.4	0.1	31.7	0.0		
90.4	10.7	42.0	0.1	32.2	0.0		
91.8	10.7	42.7	0.0	32.7	0.0		
93.2	9.4	43.3	0.0	33.2	0.0		
94.5	6.4	43.9	0.0	33.7	0.0		
95.9	6.4	44.6	0.0	34.1	0.0		
97.3	6.3	45.2	0.0	34.6	0.0		
98.6	6.1	45.9	0.0	35.1	0.0		
		46.5	0.0	35.6	0.0		
		47.1	0.0	36.1	0.0		
		47.8	0.0	36.6	0.0		
		48.4	0.0	37.1	0.0		
		49.0	0.0	37.6	0.0		
		49.7	0.0	38.0	0.0		

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
		50.3	0.0	38.5	0.0		
		51.0	0.0	39.0	0.0		
		51.6	0.0	39.5	0.0		
		52.2	0.0	40.0	0.0		
		52.9	0.0	40.5	0.0		
		53.5	0.0	41.0	0.0		
		54.1	0.0	41.5	0.0		
		54.8	0.0	42.0	0.0		
		55.4	0.0	42.4	0.0		
		56.1	0.0	42.9	0.0		
		56.7	0.0	43.4	0.0		
		57.3	0.0	43.9	0.0		
		58.0	0.0	44.4	0.0		
		58.6	0.0	44.9	0.0		
		59.2	0.0	45.4	0.0		
		59.9	0.0	45.9	0.0		
		60.5	0.0	46.3	0.0		
		61.1	0.0	46.8	0.0		
		61.8	0.0	47.3	0.0		
		62.4	0.0	47.8	0.0		
		63.1	0.0	48.3	0.0		
		63.7	0.0	48.8	0.0		
		64.3	0.0	49.3	0.0		
		65.0	0.0	49.8	0.0		
		65.6	0.0	50.2	0.0		
		66.2	0.0	50.7	0.0		
		66.9	0.0	51.2	0.0		
		67.5	0.0	51.7	0.0		
		68.2	0.0	52.2	0.0		
		68.8	0.0	52.7	0.0		
		69.4	0.0	53.2	0.0		
		70.1	0.0	53.7	0.0		
		70.7	0.0	54.1	0.0		
		71.3	0.0	54.6	0.0		
		72.0	0.0	55.1	0.0		
		72.6	0.0	55.6	0.0		
		73.2	0.0	56.1	0.0		
		73.9	0.0	56.6	0.0		
		74.5	0.0	57.1	0.0		
		75.2	0.0	57.6	0.0		

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
		75.8	0.0	58.0	0.0		
		76.4	0.0	58.5	0.0		
		77.1	0.0	59.0	0.0		
		77.7	0.0	59.5	0.0		
		78.3	0.0	60.0	0.0		
		79.0	0.0	60.5	0.0		
		79.6	0.0	61.0	0.0		
		80.3	0.0	61.5	0.0		
		80.9	0.0	62.0	0.0		
		81.5	0.0	62.4	0.0		
		82.2	0.0	62.9	0.0		
		82.8	0.0	63.4	0.0		
		83.4	0.0	63.9	0.0		
		84.1	0.0	64.4	0.0		
		84.7	0.0	64.9	0.0		
		85.4	0.0	65.4	0.0		
		86.0	0.0	65.9	0.0		
		86.6	0.0	66.3	0.0		
		87.3	0.0	66.8	0.0		
		87.9	0.0	67.3	0.0		
		88.5	0.0	67.8	0.0		
		89.2	0.0	68.3	0.0		
		89.8	0.0	68.8	0.0		
		90.4	0.0	69.3	0.0		
		91.1	0.0	69.8	0.0		
		91.7	0.0	70.2	0.0		
		92.4	0.0	70.7	0.0		
		93.0	0.0	71.2	0.0		
		93.6	0.0	71.7	0.0		
		94.3	0.0	72.2	0.0		
		94.9	0.0	72.7	0.0		
		95.5	0.0	73.2	0.0		
		96.2	0.0	73.7	0.0		
		96.8	0.0	74.1	0.0		
		97.5	0.0	74.6	0.0		
		98.1	0.0	75.1	0.0		
		98.7	0.0	75.6	0.0		
		99.4	0.0	76.1	0.0		
				76.6	0.0		
				77.1	0.0		

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
				77.6	0.0		
				78.0	0.0		
				78.5	0.0		
				79.0	0.0		
				79.5	0.0		
				80.0	0.0		
				80.5	0.0		
				81.0	0.0		
				81.5	0.0		
				82.0	0.0		
				82.4	0.0		
				82.9	0.0		
				83.4	0.0		
				83.9	0.0		
				84.4	0.0		
				84.9	0.0		
				85.4	0.0		
				85.9	0.0		
				86.3	0.0		
				86.8	0.0		
				87.3	0.0		
				87.8	0.0		
				88.3	0.0		
				88.8	0.0		
				89.3	0.0		
				89.8	0.0		
				90.2	0.0		
				90.7	0.0		
				91.2	0.0		
				91.7	0.0		
				92.2	0.0		
				92.7	0.0		
				93.2	0.0		
				93.7	0.0		
				94.1	0.0		
				94.6	0.0		
				95.1	0.0		
				95.6	0.0		
				96.1	0.0		
				96.6	0.0		

Mandawara		Shri Mahabirji		Gandhav		Ringus,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
				97.1	0.0		
				97.6	0.0		
				98.0	0.0		
				98.5	0.0		
				99.0	0.0		
				99.5	0.0		

Table 3: Flow data at various probability levels

Padardibadi,		Pipli,		Negaria,		Berami,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
0.6	2442.6	0.7	245.0	1.0	1534.2	1.6	30.3
1.3	2231.0	1.4	82.3	1.9	1139.5	3.3	6.5
1.9	1784.7	2.0	53.5	2.9	804.5	4.9	5.2
2.5	1445.0	2.7	32.9	3.9	764.3	6.6	4.0
3.2	1400.4	3.4	31.7	4.9	752.6	8.2	1.4
3.8	1392.0	4.1	14.3	5.8	654.9	9.8	0.6
4.5	1262.6	4.8	12.0	6.8	640.7	11.5	0.5
5.1	1227.5	5.4	11.7	7.8	637.8	13.1	0.2
5.7	1176.4	6.1	11.5	8.7	589.7	14.8	0.0
6.4	992.0	6.8	10.4	9.7	515.9	16.4	0.0
7.0	918.2	7.5	10.0	10.7	514.5	18.0	0.0
7.6	747.7	8.2	9.3	11.7	423.4	19.7	0.0
8.3	674.1	8.8	8.4	12.6	403.7	21.3	0.0
8.9	609.5	9.5	7.0	13.6	396.4	23.0	0.0
9.6	536.5	10.2	6.5	14.6	349.2	24.6	0.0
10.2	502.8	10.9	5.7	15.5	291.0	26.2	0.0
10.8	455.9	11.6	5.5	16.5	258.0	27.9	0.0
11.5	407.4	12.2	5.5	17.5	225.0	29.5	0.0
12.1	347.7	12.9	3.3	18.4	205.0	31.1	0.0
12.7	333.0	13.6	2.7	19.4	189.9	32.8	0.0
13.4	314.3	14.3	1.9	20.4	172.2	34.4	0.0
14.0	310.2	15.0	1.7	21.4	143.3	36.1	0.0
14.6	298.1	15.6	1.6	22.3	139.9	37.7	0.0
15.3	280.4	16.3	1.6	23.3	116.9	39.3	0.0
15.9	272.5	17.0	1.5	24.3	115.4	41.0	0.0
16.6	270.1	17.7	1.4	25.2	110.7	42.6	0.0
17.2	263.1	18.4	1.2	26.2	94.2	44.3	0.0
17.8	238.9	19.0	1.1	27.2	87.5	45.9	0.0
18.5	208.7	19.7	1.1	28.2	75.1	47.5	0.0
19.1	204.1	20.4	1.0	29.1	71.9	49.2	0.0
19.7	202.2	21.1	0.9	30.1	71.0	50.8	0.0
20.4	176.4	21.8	0.9	31.1	61.3	52.5	0.0
21.0	142.8	22.4	0.9	32.0	57.5	54.1	0.0
21.7	132.8	23.1	0.9	33.0	56.7	55.7	0.0
22.3	131.1	23.8	0.8	34.0	51.9	57.4	0.0
22.9	128.4	24.5	0.8	35.0	49.7	59.0	0.0
23.6	115.7	25.2	0.8	35.9	49.2	60.7	0.0

Padardibadi,		Pipli,		Negaria,		Berami,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
24.2	114.6	25.9	0.8	36.9	48.8	62.3	0.0
24.8	109.7	26.5	0.8	37.9	48.7	63.9	0.0
25.5	106.4	27.2	0.7	38.8	48.1	65.6	0.0
26.1	99.8	27.9	0.7	39.8	47.7	67.2	0.0
26.8	95.7	28.6	0.7	40.8	47.5	68.9	0.0
27.4	93.1	29.3	0.7	41.7	47.4	70.5	0.0
28.0	92.9	29.9	0.7	42.7	46.8	72.1	0.0
28.7	91.4	30.6	0.7	43.7	45.9	73.8	0.0
29.3	90.6	31.3	0.5	44.7	45.6	75.4	0.0
29.9	84.4	32.0	0.5	45.6	44.3	77.0	0.0
30.6	80.2	32.7	0.5	46.6	43.2	78.7	0.0
31.2	73.9	33.3	0.5	47.6	40.3	80.3	0.0
31.8	71.6	34.0	0.4	48.5	35.9	82.0	0.0
32.5	67.2	34.7	0.4	49.5	24.7	83.6	0.0
33.1	64.3	35.4	0.4	50.5	21.8	85.2	0.0
33.8	63.9	36.1	0.3	51.5	20.0	86.9	0.0
34.4	57.8	36.7	0.3	52.4	19.8	88.5	0.0
35.0	57.4	37.4	0.3	53.4	18.2	90.2	0.0
35.7	54.9	38.1	0.3	54.4	17.9	91.8	0.0
36.3	54.7	38.8	0.3	55.3	17.6	93.4	0.0
36.9	52.8	39.5	0.3	56.3	17.4	95.1	0.0
37.6	47.4	40.1	0.3	57.3	15.8	96.7	0.0
38.2	47.4	40.8	0.3	58.3	15.3	98.4	0.0
38.9	47.4	41.5	0.2	59.2	12.9		
39.5	44.5	42.2	0.2	60.2	12.1		
40.1	43.6	42.9	0.2	61.2	11.8		
40.8	36.8	43.5	0.2	62.1	11.3		
41.4	35.8	44.2	0.2	63.1	11.2		
42.0	34.8	44.9	0.2	64.1	11.0		
42.7	33.6	45.6	0.2	65.0	10.3		
43.3	30.9	46.3	0.2	66.0	7.6		
43.9	30.4	46.9	0.2	67.0	5.2		
44.6	28.3	47.6	0.1	68.0	4.0		
45.2	26.1	48.3	0.1	68.9	2.5		
45.9	24.5	49.0	0.1	69.9	2.4		
46.5	24.0	49.7	0.1	70.9	1.8		
47.1	22.6	50.3	0.1	71.8	1.6		
47.8	22.0	51.0	0.1	72.8	1.4		
48.4	21.5	51.7	0.1	73.8	1.3		
49.0	20.3	52.4	0.1	74.8	1.0		
49.7	20.2	53.1	0.1	75.7	0.8		
50.3	18.2	53.7	0.1	76.7	0.0		
51.0	18.1	54.4	0.1	77.7	0.0		
51.6	17.8	55.1	0.0	78.6	0.0		
52.2	17.6	55.8	0.0	79.6	0.0		
52.9	17.4	56.5	0.0	80.6	0.0		
53.5	17.1	57.1	0.0	81.6	0.0		
54.1	16.9	57.8	0.0	82.5	0.0		
54.8	16.8	58.5	0.0	83.5	0.0		
55.4	15.9	59.2	0.0	84.5	0.0		
56.1	15.6	59.9	0.0	85.4	0.0		
56.7	15.4	60.5	0.0	86.4	0.0		

Padardibadi,		Pipli,		Negaria,		Berami,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
57.3	15.2	61.2	0.0	87.4	0.0		
58.0	14.4	61.9	0.0	88.3	0.0		
58.6	14.1	62.6	0.0	89.3	0.0		
59.2	12.3	63.3	0.0	90.3	0.0		
59.9	11.5	63.9	0.0	91.3	0.0		
60.5	11.4	64.6	0.0	92.2	0.0		
61.1	11.4	65.3	0.0	93.2	0.0		
61.8	11.2	66.0	0.0	94.2	0.0		
62.4	10.9	66.7	0.0	95.1	0.0		
63.1	10.6	67.3	0.0	96.1	0.0		
63.7	10.5	68.0	0.0	97.1	0.0		
64.3	10.4	68.7	0.0	98.1	0.0		
65.0	10.4	69.4	0.0	99.0	0.0		
65.6	10.3	70.1	0.0				
66.2	9.9	70.7	0.0				
66.9	9.5	71.4	0.0				
67.5	9.0	72.1	0.0				
68.2	8.9	72.8	0.0				
68.8	8.7	73.5	0.0				
69.4	8.3	74.1	0.0				
70.1	8.1	74.8	0.0				
70.7	8.0	75.5	0.0				
71.3	7.8	76.2	0.0				
72.0	7.2	76.9	0.0				
72.6	6.7	77.6	0.0				
73.2	6.6	78.2	0.0				
73.9	6.4	78.9	0.0				
74.5	6.2	79.6	0.0				
75.2	6.1	80.3	0.0				
75.8	5.0	81.0	0.0				
76.4	4.7	81.6	0.0				
77.1	4.6	82.3	0.0				
77.7	4.5	83.0	0.0				
78.3	3.9	83.7	0.0				
79.0	3.6	84.4	0.0				
79.6	3.5	85.0	0.0				
80.3	2.3	85.7	0.0				
80.9	2.2	86.4	0.0				
81.5	2.2	87.1	0.0				
82.2	2.1	87.8	0.0				
82.8	1.9	88.4	0.0				
83.4	1.4	89.1	0.0				
84.1	1.3	89.8	0.0				
84.7	1.0	90.5	0.0				
85.4	1.0	91.2	0.0				
86.0	0.2	91.8	0.0				
86.6	0.0	92.5	0.0				
87.3	0.0	93.2	0.0				
87.9	0.0	93.9	0.0				
88.5	0.0	94.6	0.0				
89.2	0.0	95.2	0.0				
89.8	0.0	95.9	0.0				

Padardibadi,		Pipli,		Negaria,		Berami,	
Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr	Probability, %	Mm^3/yr
90.4	0.0	96.6	0.0				
91.1	0.0	97.3	0.0				
91.7	0.0	98.0	0.0				
92.4	0.0	98.6	0.0				
93.0	0.0	99.3	0.0				
93.6	0.0						
94.3	0.0						
94.9	0.0						
95.5	0.0						
96.2	0.0						
96.8	0.0						
97.5	0.0						
98.1	0.0						
98.7	0.0						
99.4	0.0						

Appendix 14

Present and Projected Productivity of Crops Grown in Rajasthan

1 Crop Area and Productivity

1.1 Introduction

An analysis of available data from Department of Agriculture, Rajasthan on major crops, areas sown, production, productivity and rainfall from 1980 to 2010 was carried out, and trends were accordingly identified to enable forecasting the productivity of main field crops for the target years of 2020, 2040 and 2060.

The following tables and diagrams present for every main crop the year-by-year figures of sown area, in million hectares; crop production, in million tons; productivity, in kg per hectare; and annual rainfall, in millimetres.

1.2 Bajra

Table 1 Area Sown, Production and Productivity of Bajra, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	5.0	1.1	226	427
1981	4.9	0.8	163	562
1982	4.8	1.4	289	560
1983	5.0	2.5	491	621
1984	4.4	1.6	366	475
1985	4.8	0.7	153	503
1986	5.3	1.0	192	464
1987	3.6	0.5	130	315
1988	5.7	2.7	472	534
1989	4.9	1.8	371	455
1990	4.9	2.5	513	727
1991	4.6	1.1	233	493
1992	5.0	2.9	578	650
1993	4.4	1.0	240	537
1994	5.0	2.6	516	688
1995	4.3	1.2	271	621
1996	4.7	2.3	492	757
1997	4.7	2.5	534	691
1998	4.2	1.8	430	589
1999	3.9	1.3	329	490
2000	4.6	2.0	441	404
2001	5.1	3.8	744	538
2002	3.2	0.7	223	267
2003	5.9	6.7	1,137	588
2004	4.6	3.0	656	513
2005	5.0	2.2	434	570
2006	4.9	3.4	701	688
2007	5.1	4.2	832	514

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
2008	5.2	4.3	825	555
2009	5.2	2.0	394	437
2010	5.5	6.1	1,110	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 1 Annual Area and Production of Bajra

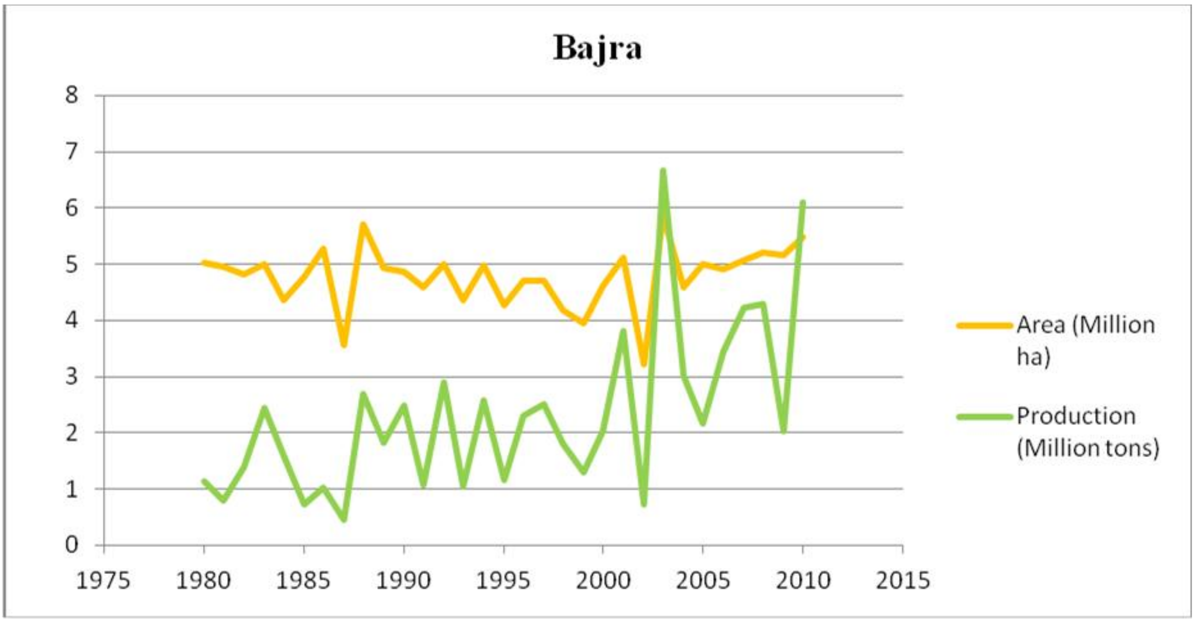
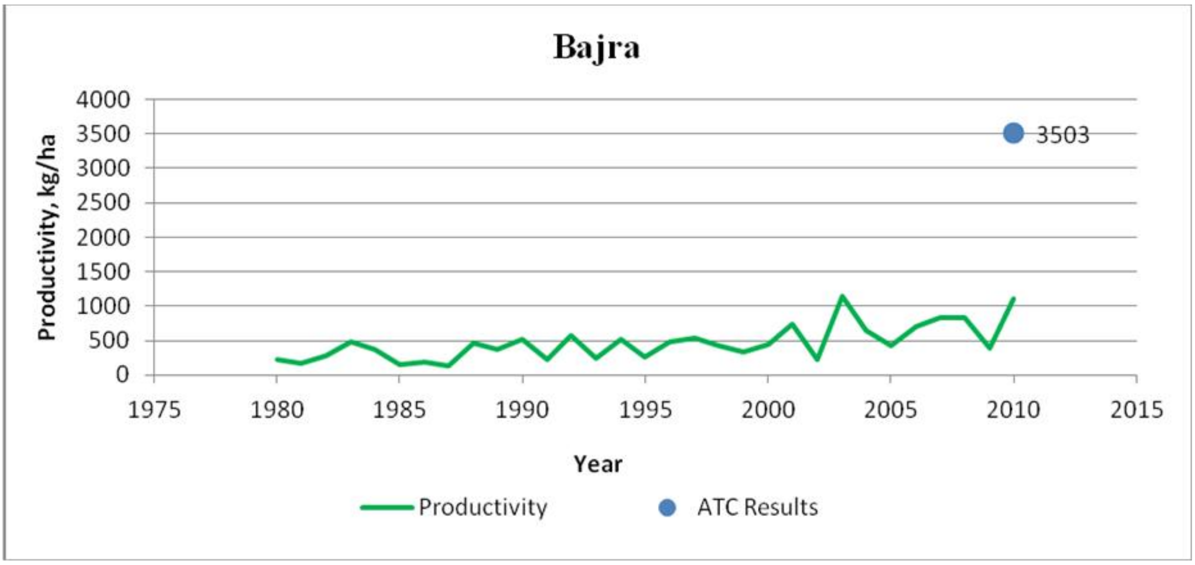


Figure 2 Annual Productivity and ATC Results of Bajra



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 3 Growth Trends in Area and Production of Bajra

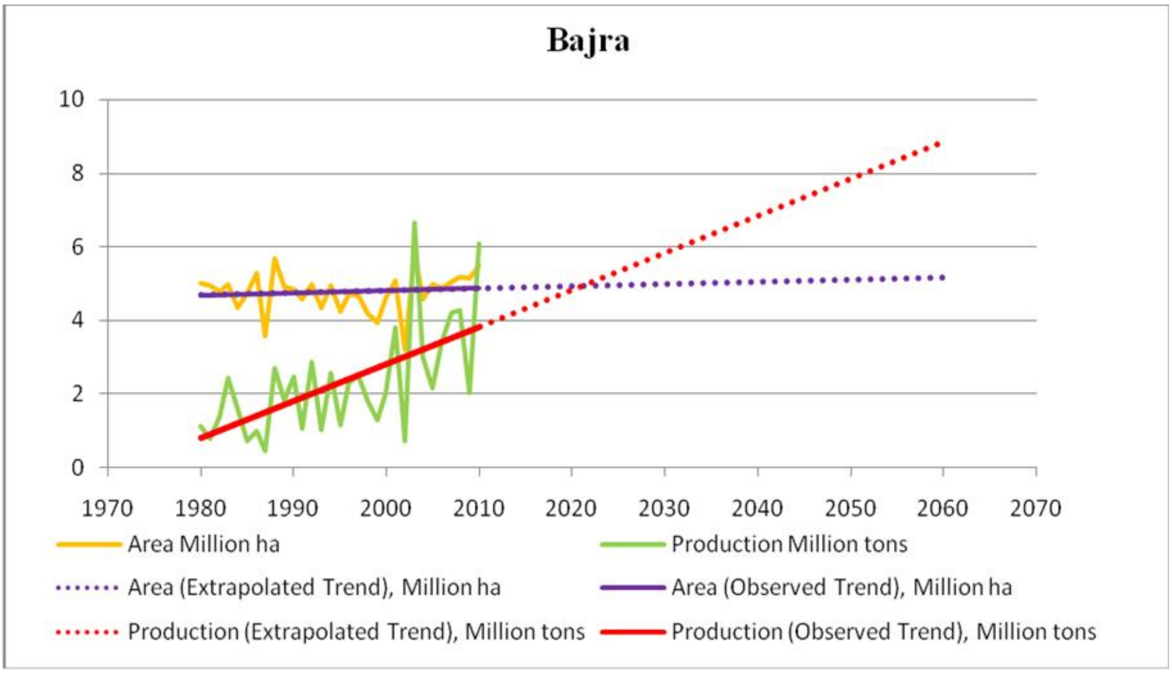


Table 2 Projections of Area Sown, Production and Productivity of Bajra

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	4.9	5.5	1,122
2040	5.0	6.7	1,340
2060	5.2	8.8	1,692

The productivity of Bajra attained in Adaptive Trial Centres (ATC) and by excelling cultivators during the year 2010 was 3,503 kg/ha and 3,421 kg/ha respectively.

1.3 Barley

Table 3 Area Sown, Production and Productivity of Barley, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.4	0.5	1,270	427
1981	0.5	0.5	1,064	562
1982	0.3	0.5	1,383	560
1983	0.3	0.4	1,481	621
1984	0.3	0.4	1,457	475
1985	0.3	0.6	1,760	503
1986	0.3	0.4	1,454	464
1987	0.2	0.4	1,556	315
1988	0.2	0.4	1,719	534
1989	0.2	0.3	1,587	455

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1990	0.2	0.4	1,872	727
1991	0.3	0.5	1,841	493
1992	0.2	0.4	1,540	650
1993	0.2	0.2	1,385	537
1994	0.2	0.4	1,850	688
1995	0.2	0.4	1,985	621
1996	0.2	0.4	2,005	757
1997	0.3	0.5	1,911	691
1998	0.2	0.4	1,976	589
1999	0.2	0.4	2,020	490
2000	0.2	0.4	1,814	404
2001	0.2	0.4	2,572	538
2002	0.2	0.4	2,329	267
2003	0.2	0.4	2,248	588
2004	0.2	0.4	2,374	513
2005	0.2	0.5	2,272	570
2006	0.2	0.6	2,547	688
2007	NA	NA	NA	514
2008	0.3	0.9	3,061	555
2009	0.2	0.6	2,774	437
2010	0.3	1.0	2,911	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 4 Annual Area and Production of Barley

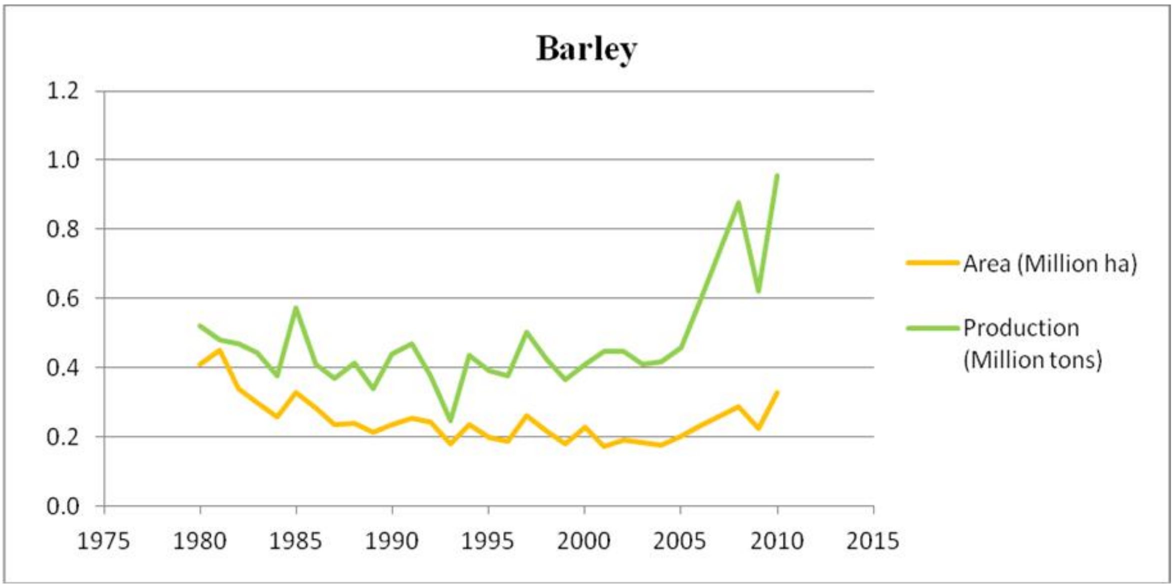
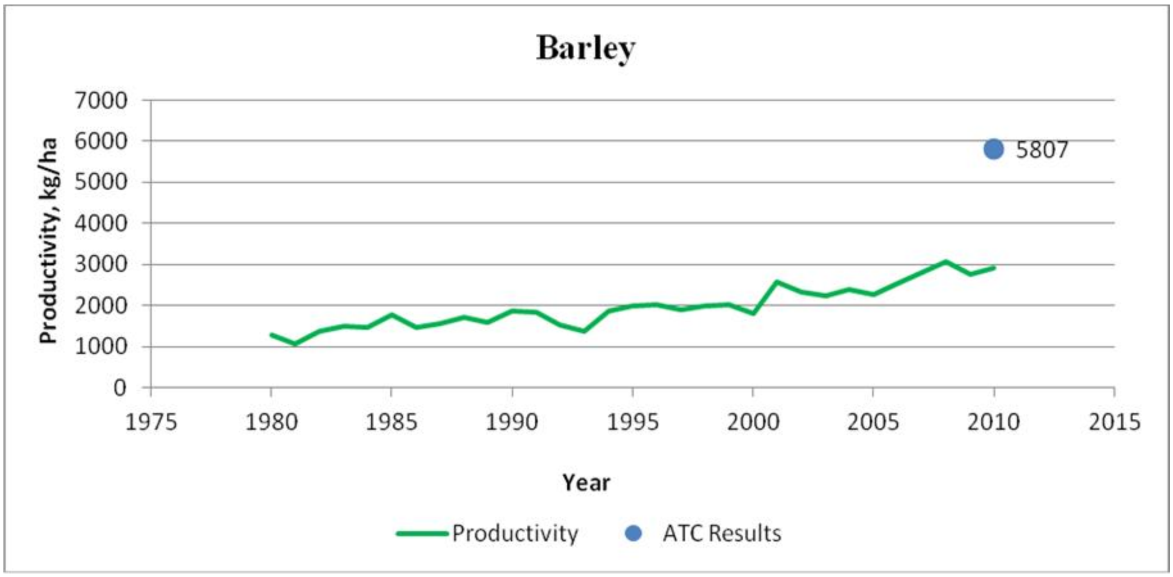


Figure 5 Annual Productivity and ATC Results of Barley



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 6 Growth Trends in of Area and Production of Barley

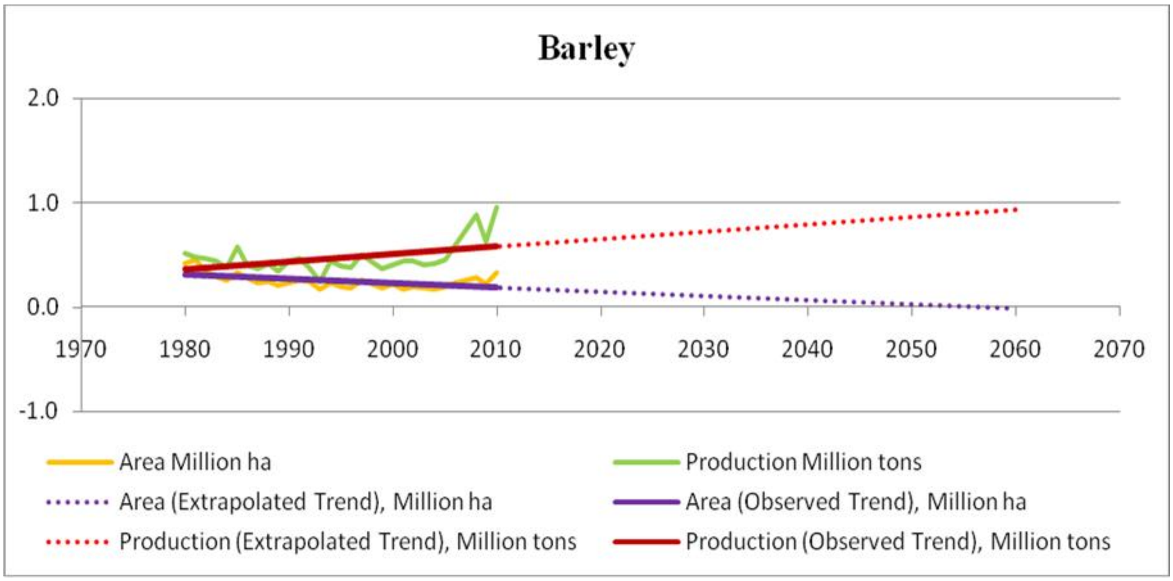


Table 4 Projections of Area Sown, Production and Productivity of Barley

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.15	0.64	4,267
2040	0.12	0.67	5,583
2060	0.00	0.00	0.00

The productivity of Barley attained in Adaptive Trial Centres (ATC) during the year 2010 was 5,807 kg/ha.

1.4 Castor

Table 5 Area Sown, Production and Productivity of Castor, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.004	0.001	207	427
1981	0.006	0.001	156	562
1982	0.005	0.001	207	560
1983	0.009	0.002	206	621
1984	0.019	0.005	244	475
1985	0.010	0.002	200	503
1986	0.006	0.001	147	464
1987	0.002	0.001	302	315
1988	0.008	0.003	407	534
1989	0.018	0.023	1,275	455
1990	0.028	0.030	1,080	727
1991	0.012	0.008	641	493
1992	0.013	0.015	1,130	650
1993	0.015	0.009	588	537
1994	0.025	0.020	816	688
1995	0.039	0.044	1,135	621
1996	0.036	0.048	1,352	757
1997	0.037	0.047	1,287	691
1998	0.040	0.055	1,386	589
1999	0.079	0.040	504	490
2000	0.121	0.046	380	404
2001	0.046	0.066	1,437	538
2002	0.026	0.022	839	267
2003	0.064	0.090	1,412	588
2004	0.110	0.104	946	513
2005	0.128	0.101	793	570
2006	0.092	0.101	1,096	688
2007	0.110	0.159	1,452	514
2008	0.147	0.194	1,316	555
2009	0.117	0.086	735	437
2010	0.149	0.211	1,417	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 7 Annual Area and Production of Castor

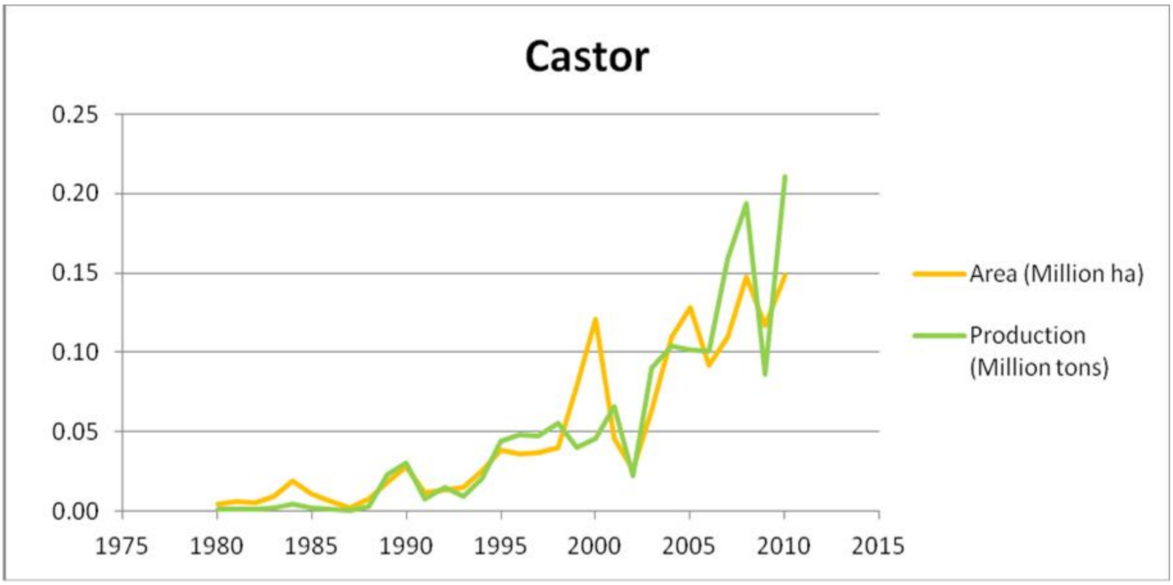
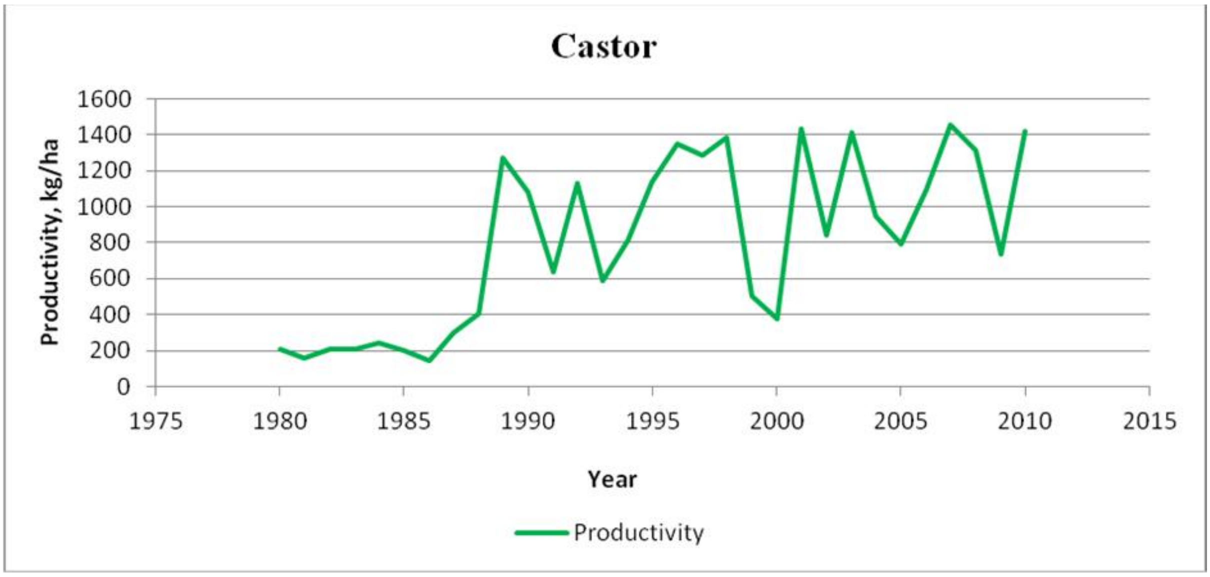


Figure 8 Annual Productivity of Castor



Source: Department of Agriculture, Rajasthan, Jaipur

Note: No trials on castor have been carried out in ATCs

Figure 9 Growth Trends in Area and Production of Castor

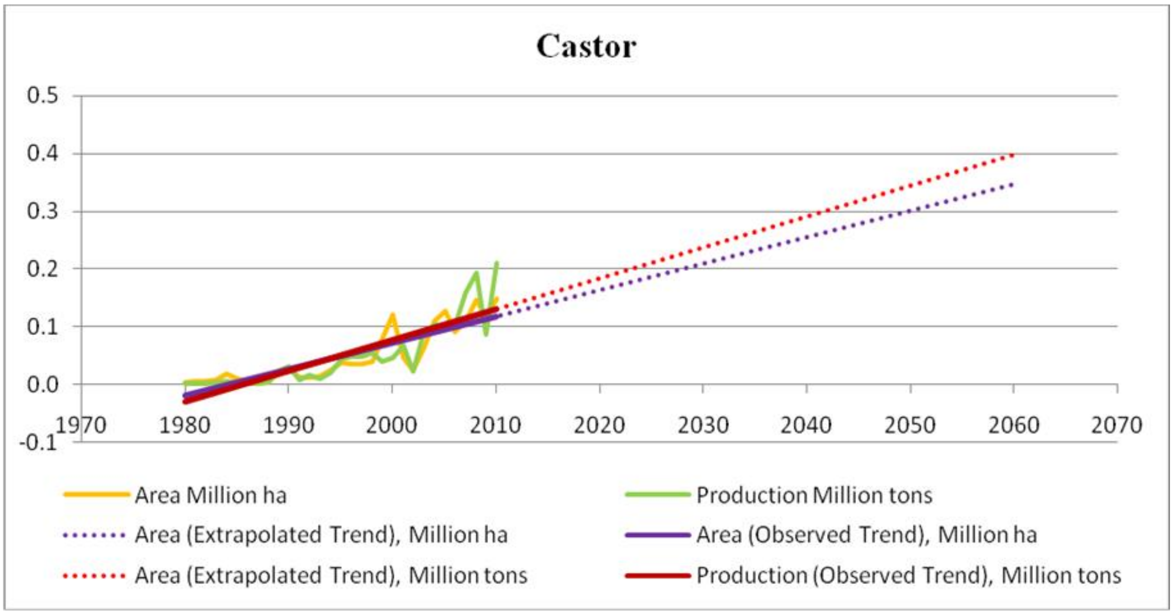


Table 6 Projections of Area Sown, Production and Productivity of Castor

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.163	0.280	1,718
2040	0.255	0.621	2,435
2060	0.346	0.988	2,855

1.5 Cluster Bean

Table 7 Area Sown, Production and Productivity of Cluster Bean, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	2.0	0.3	160	427
1981	1.7	0.3	188	562
1982	2.0	0.3	141	560
1983	2.2	0.7	300	621
1984	2.0	0.4	177	475
1985	1.8	0.1	78	503
1986	1.8	0.1	75	464
1987	0.9	0.0	30	315
1988	2.1	0.6	272	534
1989	2.0	0.4	226	455
1990	2.1	0.9	453	727
1991	1.6	0.2	131	493
1992	1.8	0.6	320	650
1993	1.9	0.3	151	537
1994	2.0	0.7	361	688

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1995	1.8	0.3	155	621
1996	1.8	0.7	407	757
1997	2.0	0.7	370	691
1998	1.6	0.3	198	589
1999	2.6	0.2	87	490
2000	3.1	0.5	157	404
2001	2.4	0.8	316	538
2002	0.6	0.0	50	267
2003	2.3	1.2	511	588
2004	1.9	0.4	189	513
2005	2.4	0.6	243	570
2006	2.8	0.7	234	688
2007	2.9	1.2	427	514
2008	3.3	1.3	380	555
2009	2.6	0.2	78	437
2010	3.0	1.5	515	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 10 Annual Area and Production of Cluster Bean

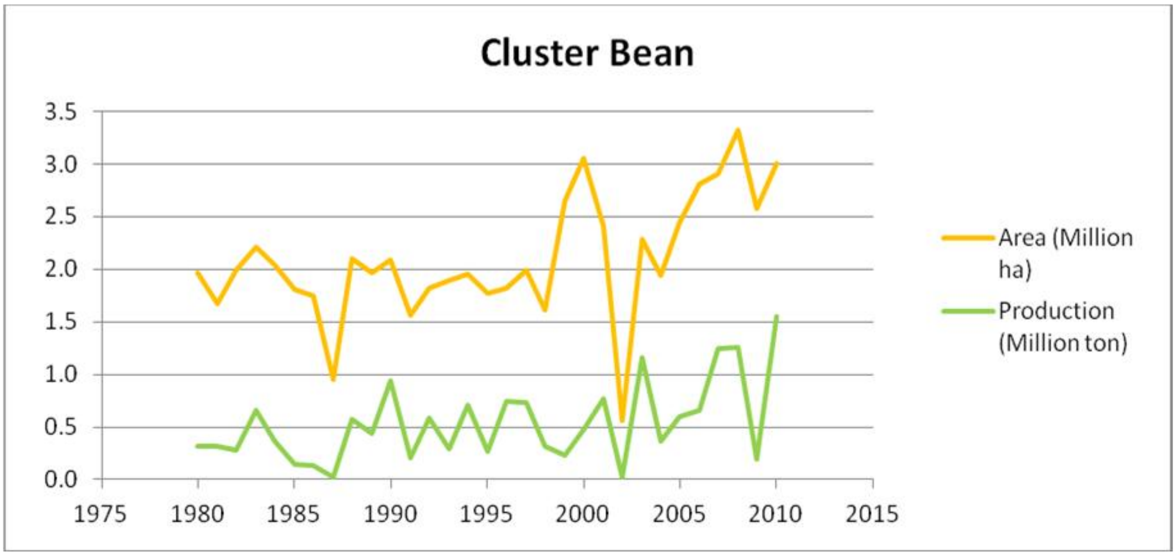
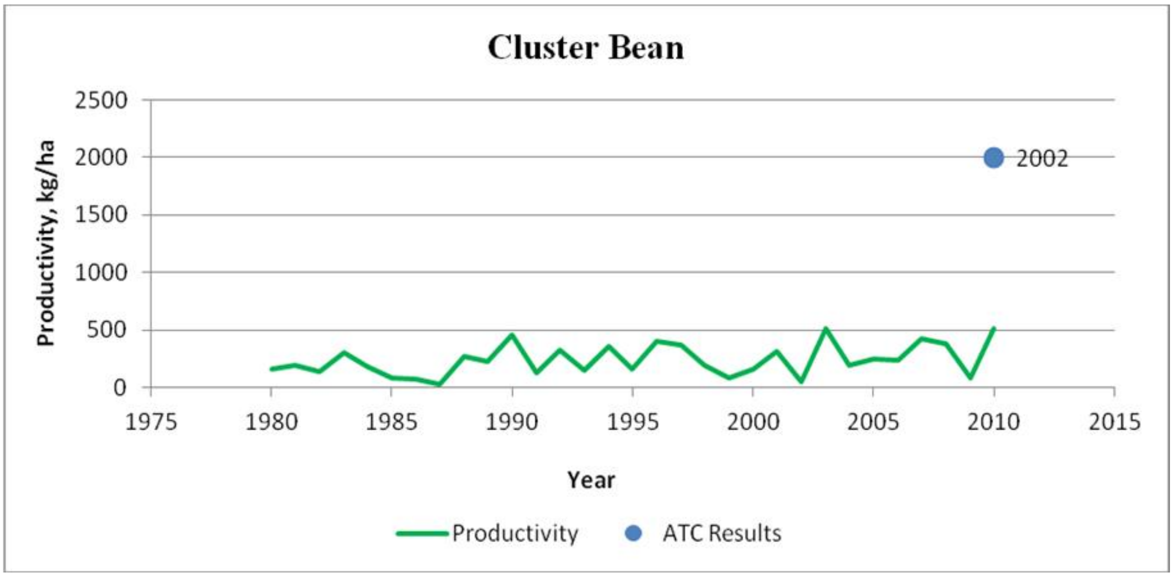


Figure 11 Annual Productivity and ATC Results of Cluster Bean



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 12 Growth Trends in Area and Production of Cluster Bean

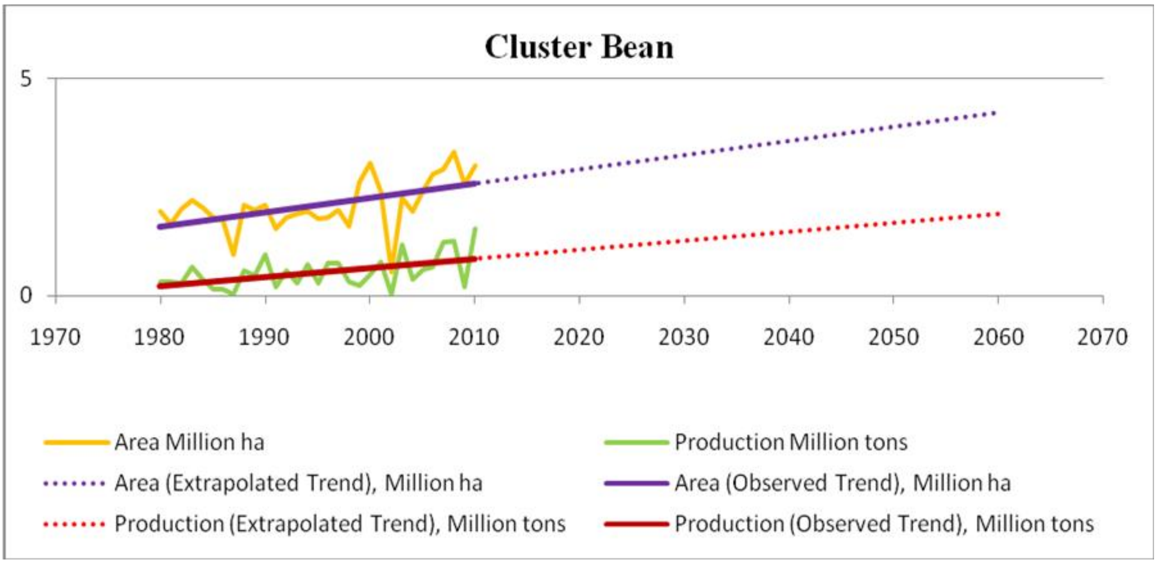


Table 8 Projections of Area Sown, Production and Productivity of Cluster Bean

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	2.9	1.5	517
2040	3.6	1.9	528
2060	4.2	2.5	595

The productivity of Cluster Bean attained in Adaptive Trial Centres (ATC) during year 2010 was ~2,002 kg/ha.

1.6 Coriander

Table 9 Area Sown, Production and Productivity of Coriander, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.06	0.04	568	427
1981	0.11	0.06	533	562
1982	0.11	0.07	667	560
1983	0.11	0.06	500	621
1984	0.10	0.03	291	475
1985	0.12	0.04	310	503
1986	0.12	0.10	822	464
1987	0.23	0.17	730	315
1988	0.13	0.10	763	534
1989	0.11	0.07	688	455
1990	0.13	0.14	1,065	727
1991	0.11	0.07	658	493
1992	0.14	0.11	737	650
1993	0.16	0.11	673	537
1994	0.12	0.09	754	688
1995	0.14	0.12	845	621
1996	0.16	0.15	985	757
1997	0.23	0.21	924	691
1998	0.20	0.18	906	589
1999	0.12	0.13	1,029	490
2000	0.15	0.17	1,146	404
2001	0.20	0.23	1,143	538
2002	0.11	0.12	1,092	267
2003	0.24	0.30	1,243	588
2004	0.15	0.17	1,144	513
2005	0.14	0.14	1,041	570
2006	0.13	0.16	1,183	688
2007	NA	NA	NA	514
2008	0.25	0.27	1,116	555
2009	0.23	0.28	1,211	437
2010	0.20	0.22	1,106	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 13 Annual Area and Production of Coriander,

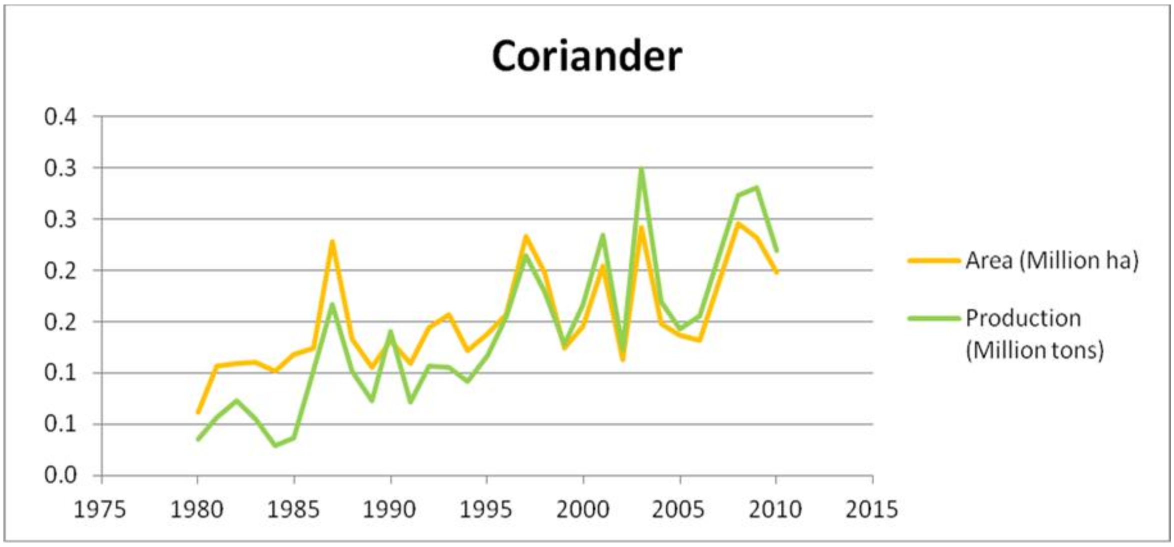
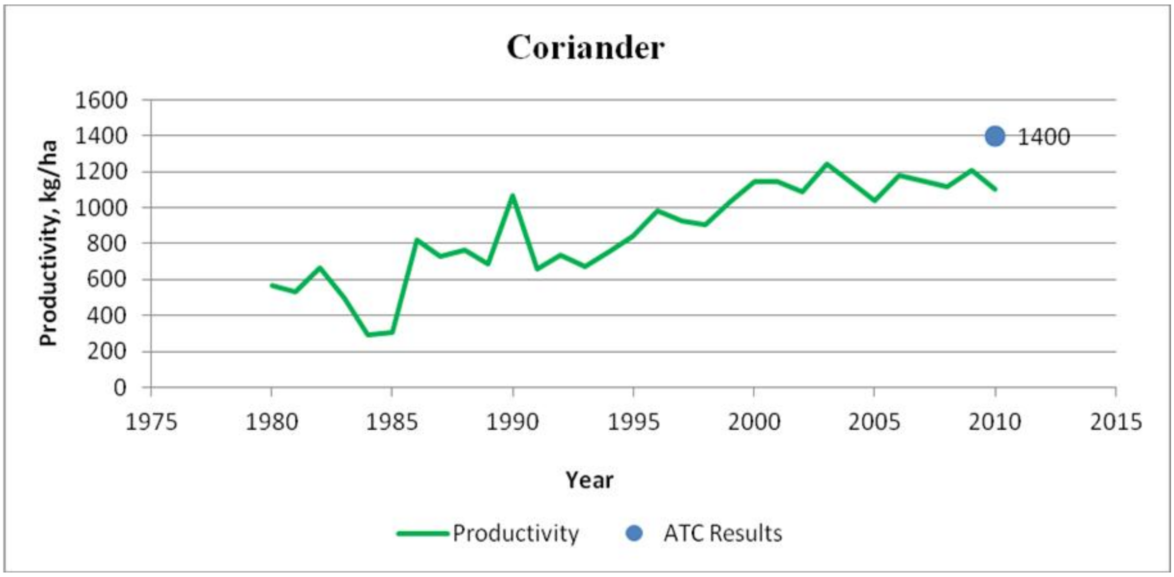


Figure 14 Annual Productivity and ATC Results of Coriander



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 15 Growth Trends in Area and Production of Coriander

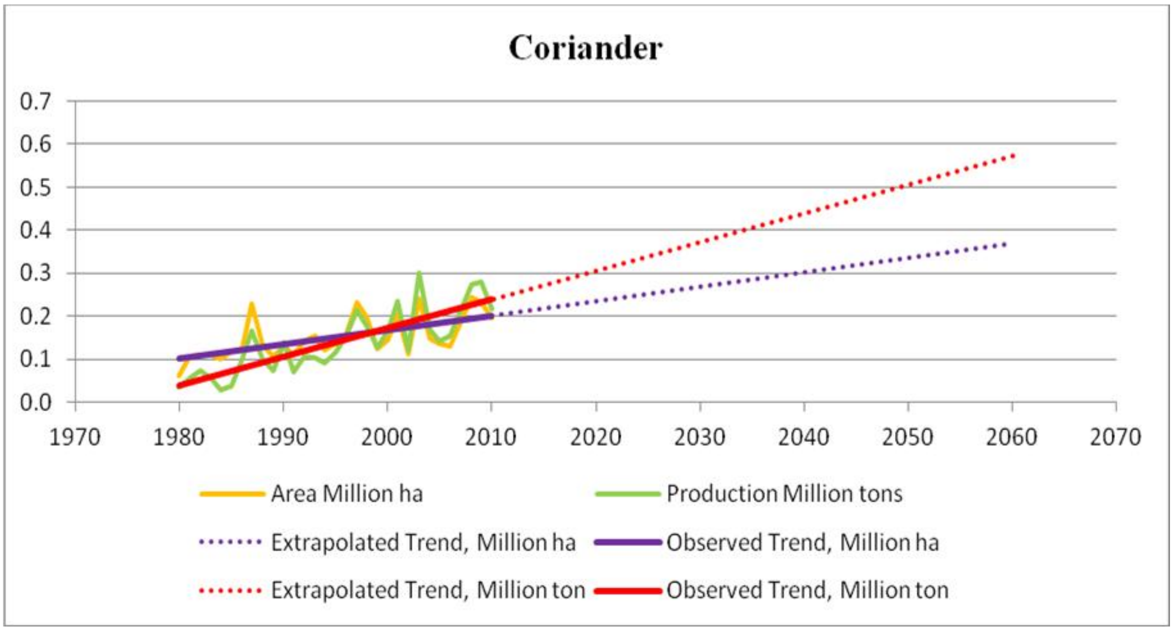


Table 10 Projections of Area Sown, Production and Productivity of Coriander

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.24	0.36	1,500
2040	0.30	0.61	2,033
2060	0.37	0.94	2,541

The productivity of Coriander attained in Adaptive Trial Centres (ATC) during the year 2010 was 1,400 kg/ha.

1.7 Cowpea

Table 11 Area Sown, Production and Productivity of Cowpeas, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.13	0.00	37	427
1981	0.14	0.01	67	562
1982	0.13	0.01	63	560
1983	0.13	0.04	329	621
1984	0.13	0.03	224	475
1985	0.15	0.00	23	503
1986	0.11	0.00	17	464
1987	0.06	0.00	72	315
1988	0.07	0.03	457	534
1989	0.08	0.01	184	455
1990	0.08	0.03	362	727
1991	0.09	0.01	63	493

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1992	0.09	0.04	434	650
1993	0.10	0.01	129	537
1994	0.08	0.03	331	688
1995	0.10	0.02	216	621
1996	0.12	0.04	360	757
1997	0.10	0.03	339	691
1998	0.11	0.02	222	589
1999	0.11	0.01	120	490
2000	0.10	0.02	203	404
2001	0.14	0.05	346	538
2002	0.11	0.01	96	267
2003	0.11	0.06	551	588
2004	0.13	0.04	312	513
2005	0.13	0.03	208	570
2006	0.11	0.04	409	688
2007	0.13	0.05	358	514
2008	0.12	0.06	529	555
2009	0.12	0.01	94	437
2010	0.12	0.06	529	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 16 Annual Area and Production of Cowpea

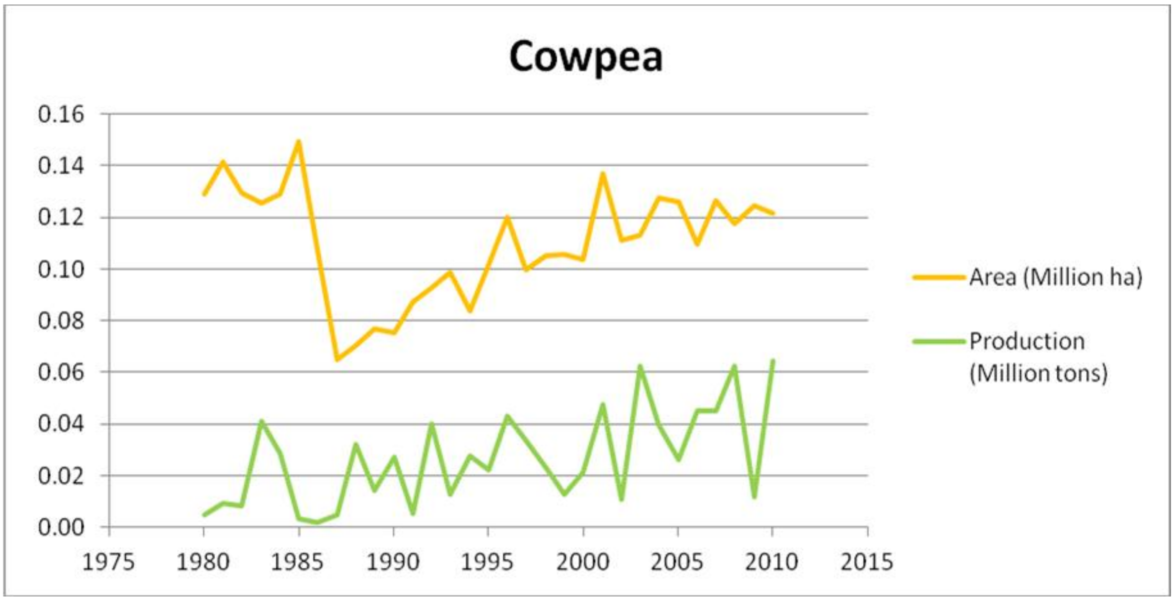
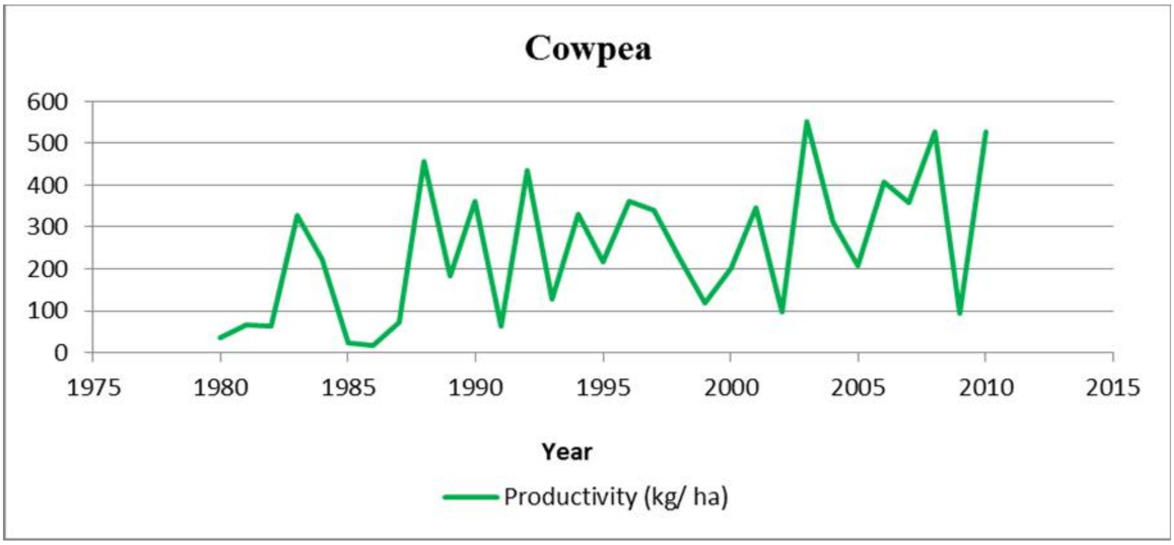


Figure 17 Annual Productivity of Cowpea



Source: Department of Agriculture, Rajasthan, Jaipur

Note: No trials on cowpea have been carried out in ATCs

Figure 18 Growth Trends in Area and Production of Cowpea

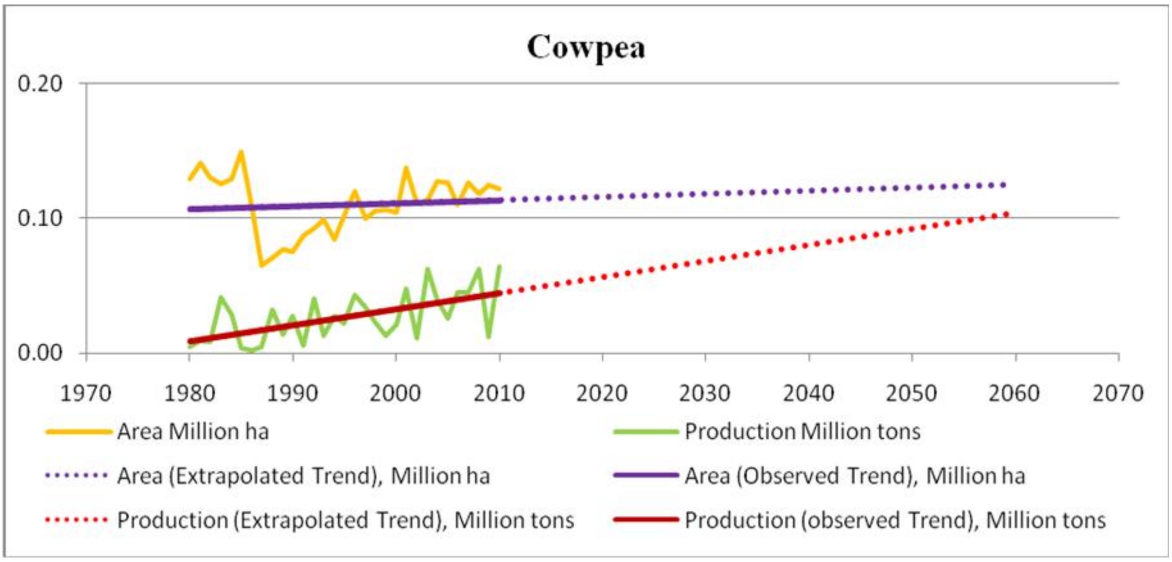


Table 12 Projections of Area Sown, Production and Productivity of Cowpea

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.11	0.06	545
2040	0.12	0.08	667
2060	0.13	0.10	769

1.8 Cumin

Table 13 Area Sown, Production and Productivity of Cumin, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	NA	NA	NA	427
1981	NA	NA	NA	562
1982	NA	NA	NA	560
1983	NA	NA	NA	621
1984	NA	NA	NA	475
1985	0.04	0.02	461	503
1986	0.04	0.02	476	464
1987	0.06	0.03	550	315
1988	0.12	0.06	524	534
1989	0.07	0.02	323	455
1990	0.05	0.03	617	727
1991	0.09	0.04	413	493
1992	0.17	0.08	445	650
1993	0.27	0.11	408	537
1994	0.15	0.06	415	688
1995	0.13	0.04	286	621
1996	0.20	0.07	332	757
1997	0.17	0.06	340	691
1998	0.15	0.06	380	589
1999	0.14	0.04	255	490
2000	0.20	0.08	384	404
2001	0.38	0.15	380	538
2002	0.32	0.07	219	267
2003	0.23	0.12	531	588
2004	0.16	0.07	433	513
2005	0.14	0.05	387	570
2006	0.15	0.02	158	688
2007	NA	NA	NA	514
2008	0.17	0.04	253	555
2009	0.20	0.08	395	437
2010	0.33	0.11	348	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 19 Annual Area and Production of Cumin

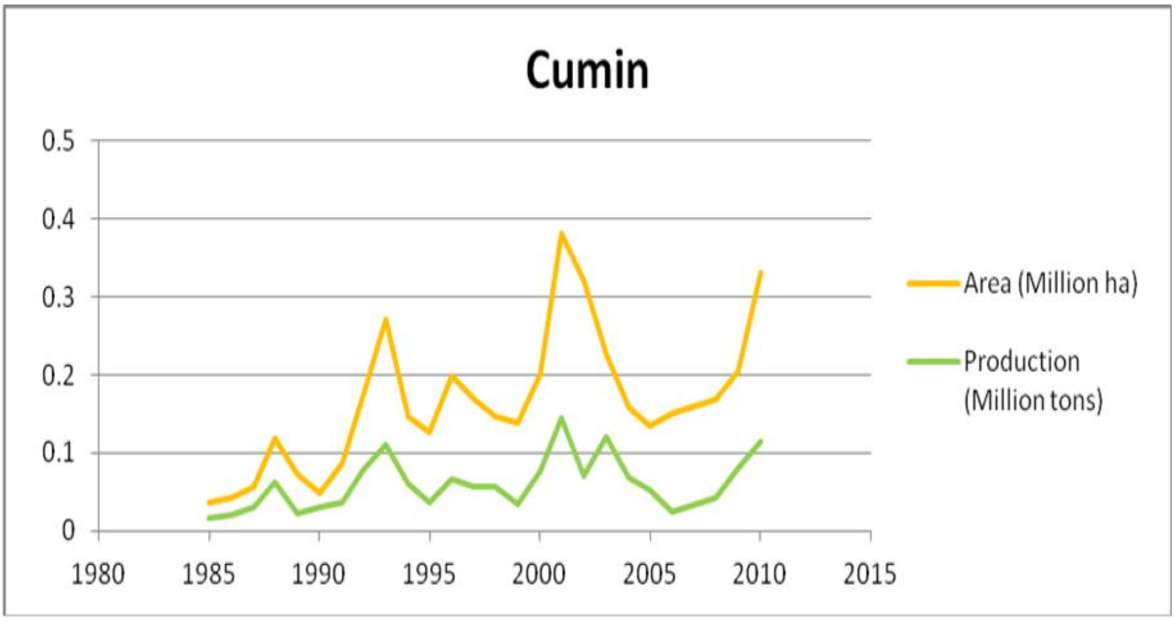
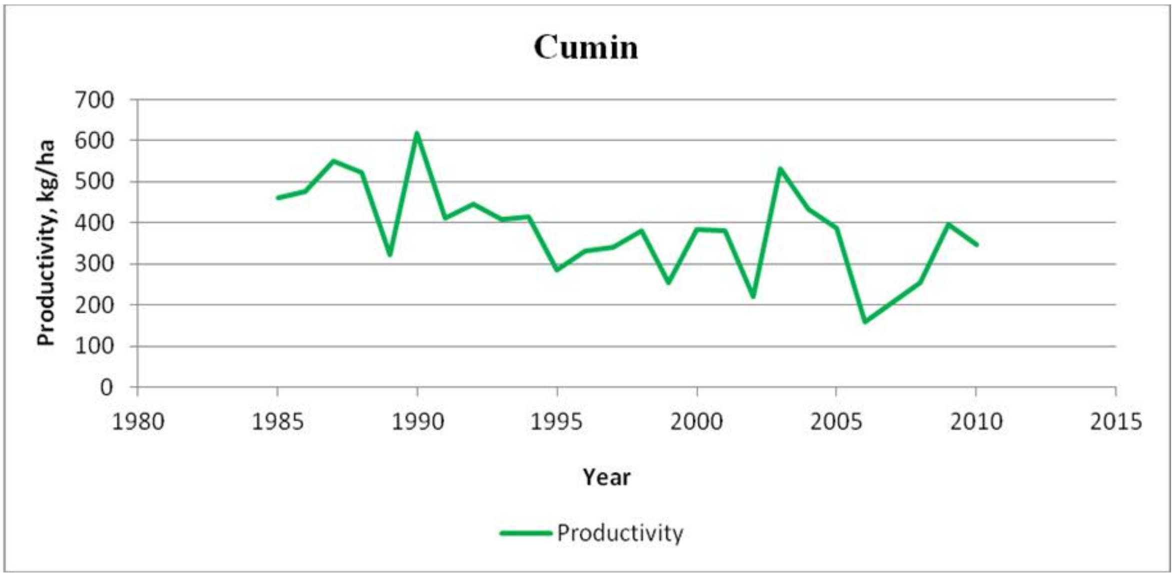


Figure 20 Annual Productivity of Cumin



Source: Department of Agriculture, Rajasthan, Jaipur

Note: No trials on cumin have been carried out in ATCs

Figure 21 Growth Trends in Area and Production of Cumin

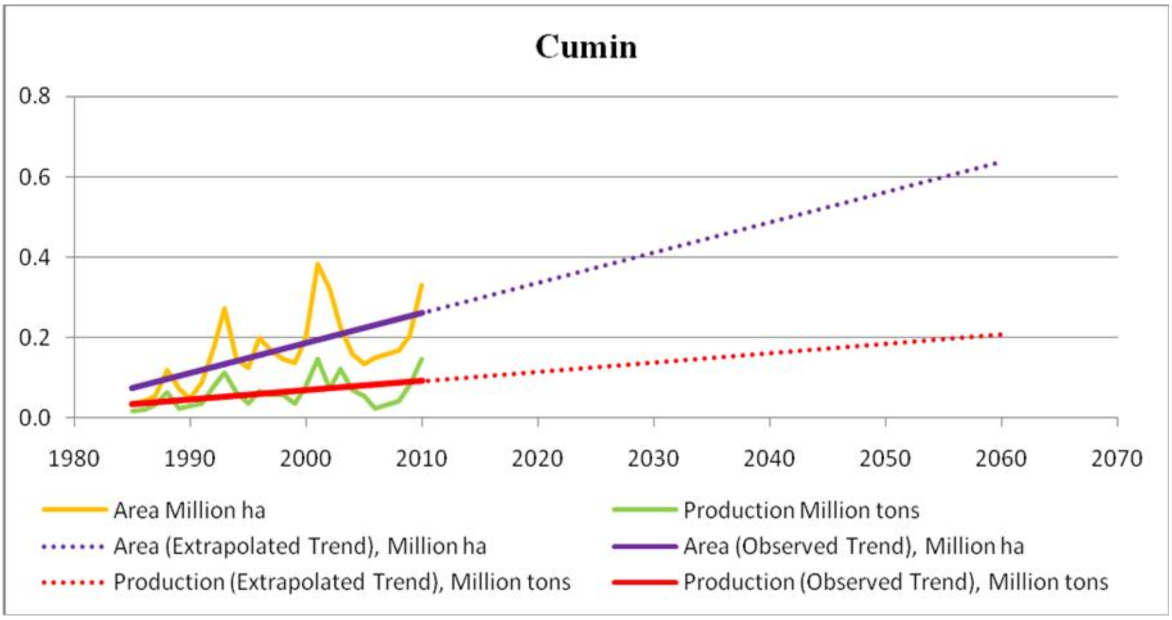


Table 14 Projections of Area Sown, Production and Productivity of Cumin

Year	Area Sown, Million ha	Production, Million ton	Productivity, kg/ha
2020	0.32	0.12	375
2040	0.45	0.18	400
2060	0.59	0.24	407

1.9 Gram

Table 15 Area Sown, Production and Productivity of Gram, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	1.23	0.85	697	427
1981	1.94	1.26	650	562
1982	1.76	1.32	751	560
1983	1.80	1.09	606	621
1984	1.53	0.97	632	475
1985	1.94	1.62	836	503
1986	1.41	0.82	583	464
1987	0.68	0.41	602	315
1988	1.28	0.97	754	534
1989	1.14	0.71	622	455
1990	1.65	1.01	612	727
1991	1.03	0.68	660	493
1992	1.45	0.79	548	650
1993	1.22	0.75	612	537
1994	1.59	1.37	864	688
1995	1.62	1.09	673	621

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1996	1.52	1.07	705	757
1997	2.21	1.92	869	691
1998	2.82	2.07	737	589
1999	0.98	0.68	695	490
2000	0.67	0.40	587	404
2001	0.97	0.74	759	538
2002	0.45	0.34	757	267
2003	1.12	0.71	633	588
2004	1.04	0.77	746	513
2005	1.08	0.48	443	570
2006	1.01	0.87	863	688
2007	NA	NA	NA	514
2008	1.26	0.98	779	555
2009	0.88	0.53	605	437
2010	1.78	1.60	898	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 22 Annual Area and Production of Gram

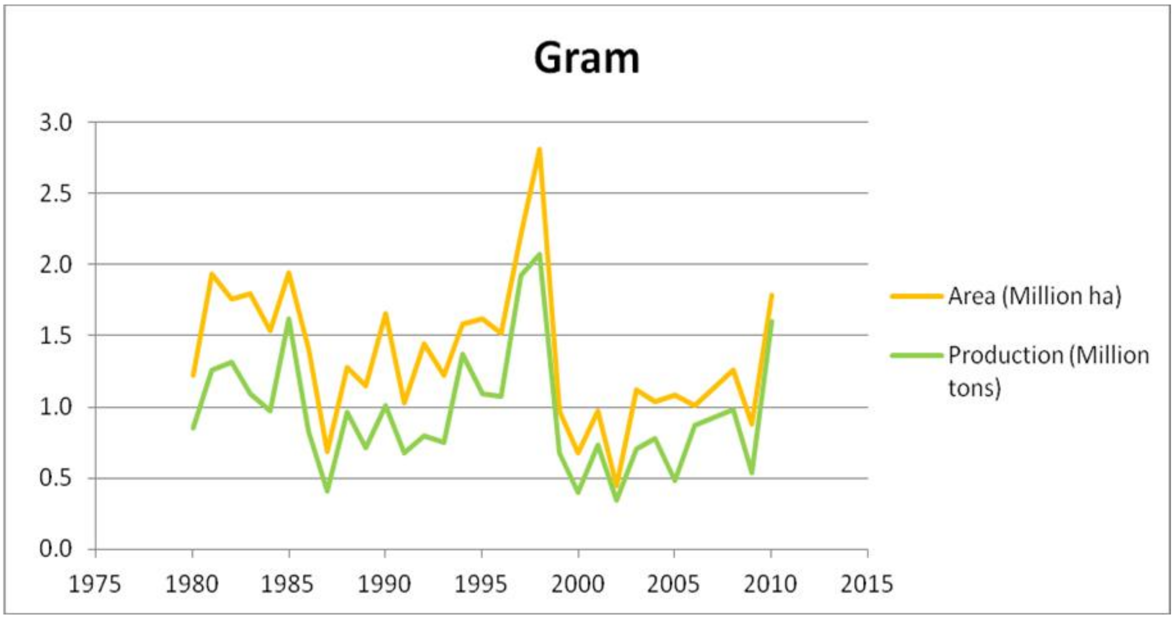
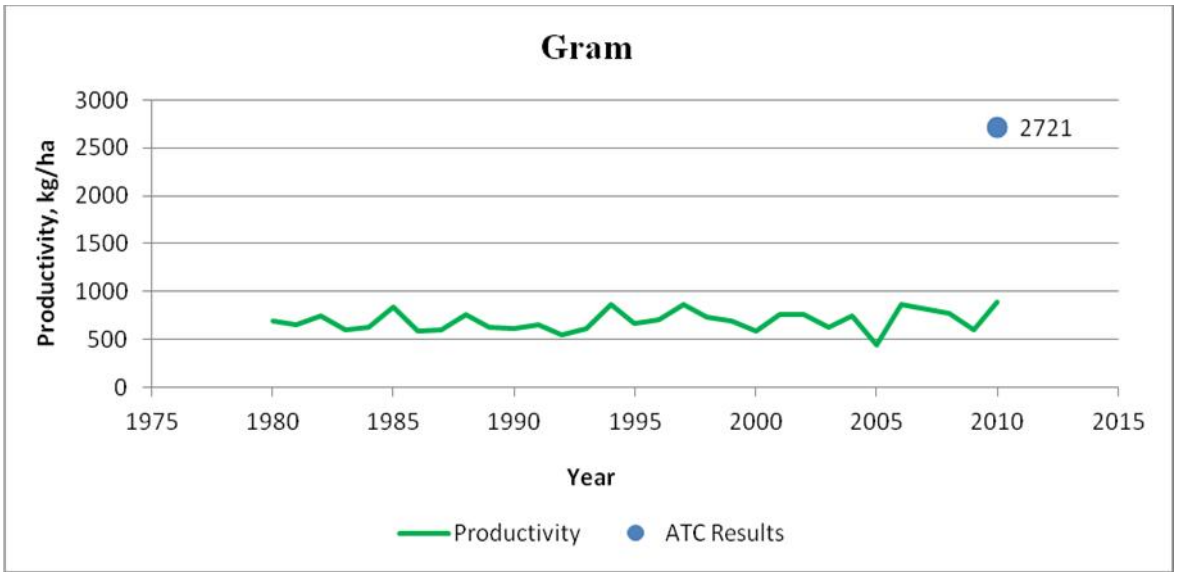


Figure 23 Annual Productivity and ATC Results of Gram



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 24 Growth Trends in Area and Production of Gram

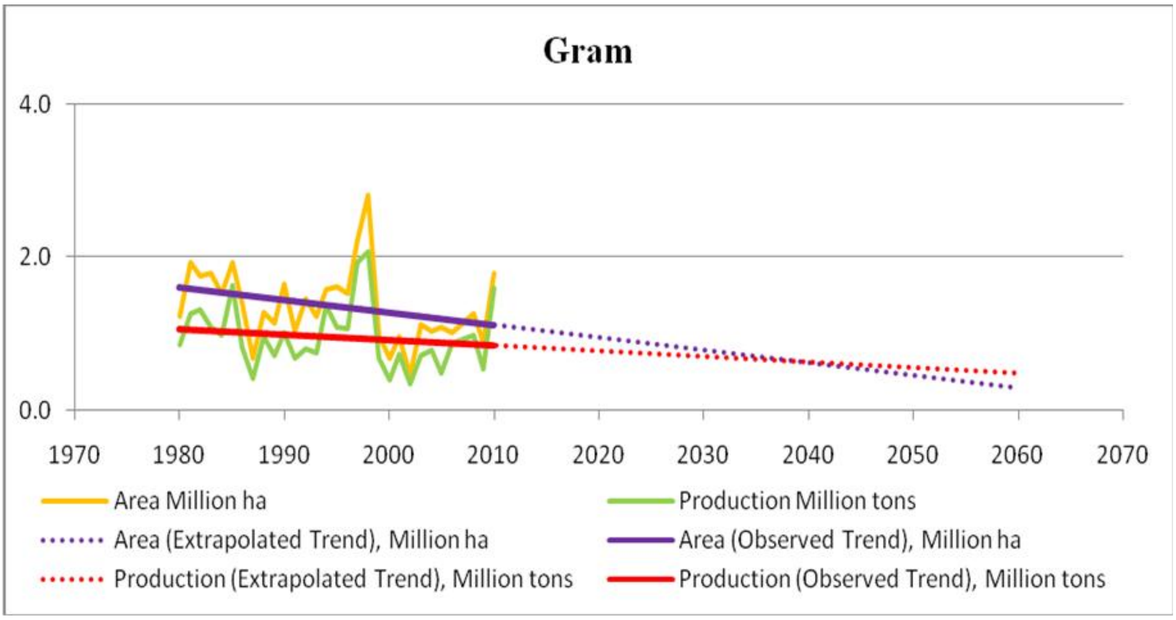


Table 16 Projections of Area Sown, Production and Productivity of Gram

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.95	0.96	1,011
2040	0.63	0.68	1,079
2060	0.30	0.37	1,233

The productivity of Gram attained in Adaptive Trial Centres (ATC) during the year 2010 was 2,721 kg/ha.

1.10 Groundnuts

Table 17 Area Sown, Production and Productivity of Groundnuts, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.21	0.09	405	427
1981	0.16	0.11	669	562
1982	0.19	0.11	572	560
1983	0.18	0.17	949	621
1984	0.25	0.17	684	475
1985	0.25	0.15	611	503
1986	0.20	0.13	647	464
1987	0.23	0.14	607	315
1988	0.23	0.26	1,109	534
1989	0.28	0.21	775	455
1990	0.23	0.22	942	727
1991	0.25	0.20	798	493
1992	0.24	0.27	1,119	650
1993	0.29	0.21	728	537
1994	0.25	0.20	790	688
1995	0.22	0.16	762	621
1996	0.25	0.27	1,112	757
1997	0.33	0.37	1,122	691
1998	0.33	0.36	1,091	589
1999	0.27	0.26	961	490
2000	0.20	0.18	924	404
2001	0.24	0.30	1,226	538
2002	0.24	0.17	687	267
2003	0.21	0.33	1,565	588
2004	0.29	0.45	1,550	513
2005	0.32	0.50	1,547	570
2006	0.31	0.40	1,305	688
2007	0.28	0.48	1,727	514
2008	0.32	0.54	1,667	555
2009	0.33	0.35	1,087	437
2010	0.35	0.68	1,963	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 25 Annual Area and Production of Groundnuts

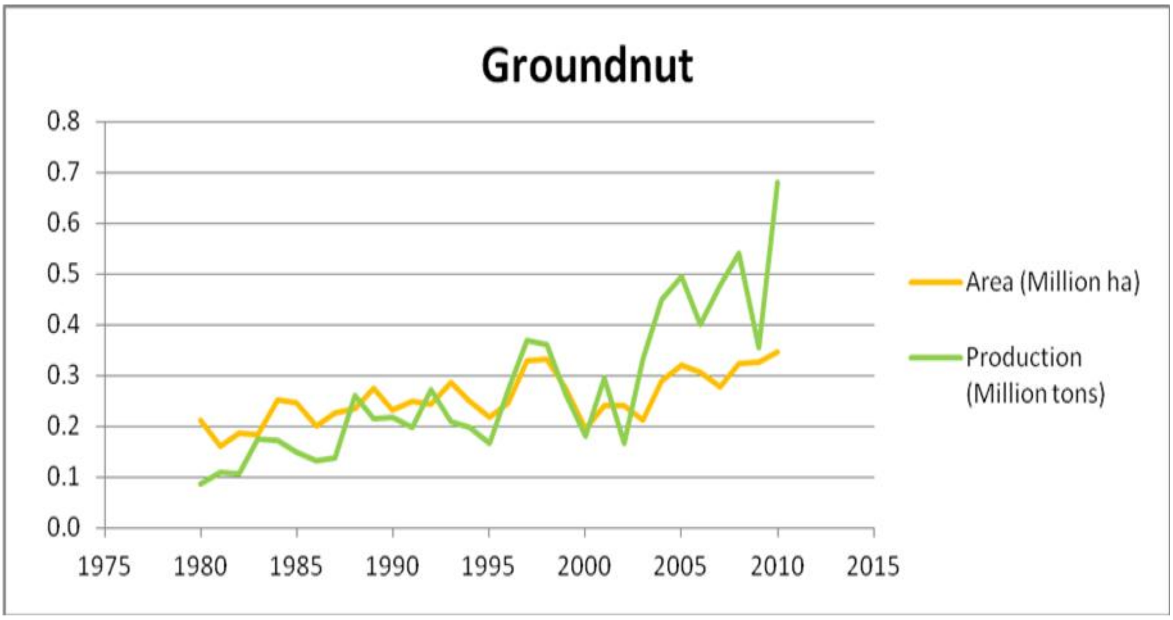
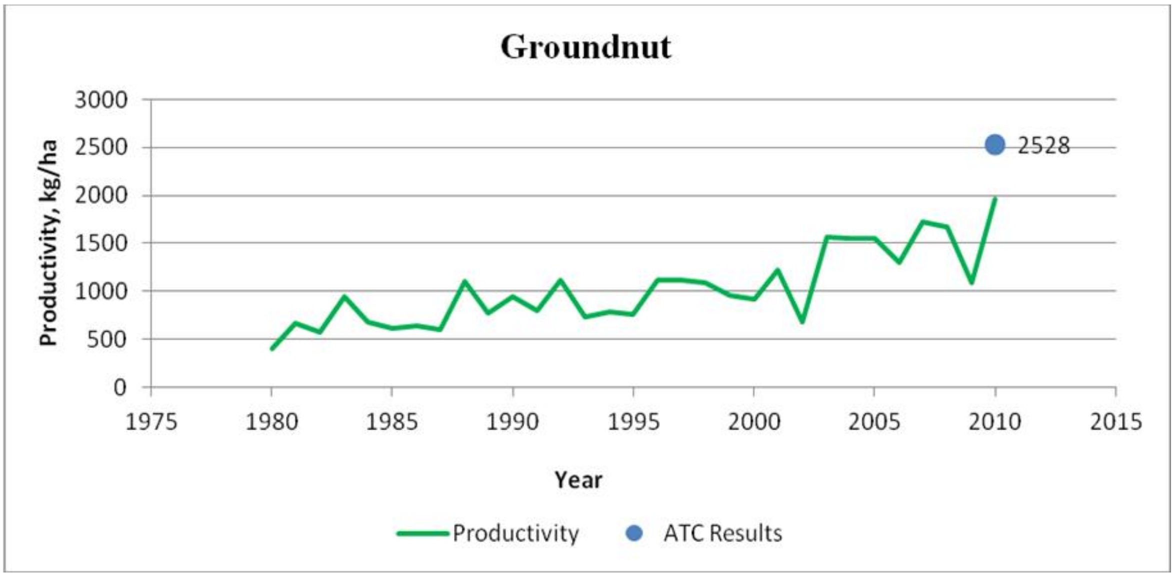


Figure 26 Annual Productivity and ATC Results of Groundnut



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 27 Growth Trends in Area and Production of Groundnuts

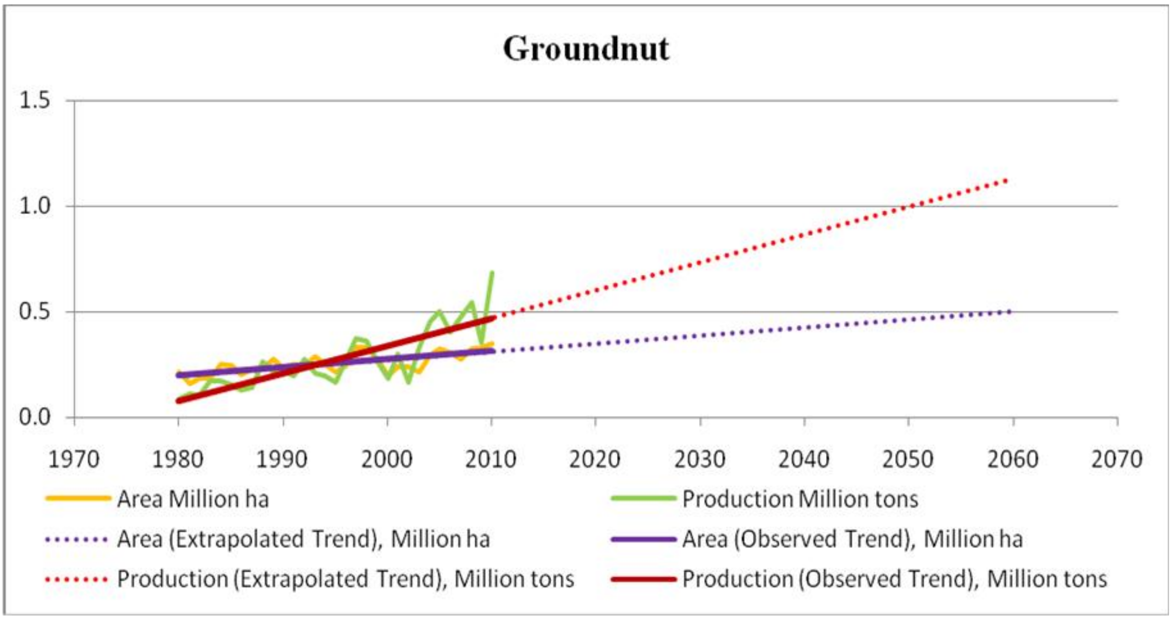


Table 18 Projections of Area Sown, Production and Productivity of Groundnut

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.35	0.73	2,086
2040	0.43	0.97	2,256
2060	0.50	1.54	3,080

The productivity of groundnuts attained in Adaptive Trial Centres (ATC) during the year 2010 was 2,528 kg/ha.

1.11 Isabgol

Table 19 Area Sown, Production and Productivity of Isabgol, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	NA	NA	NA	427
1981	NA	NA	NA	562
1982	NA	NA	NA	560
1983	NA	NA	NA	621
1984	NA	NA	NA	475
1985	NA	NA	NA	503
1986	NA	NA	NA	464
1987	NA	NA	NA	315
1988	NA	NA	NA	534
1989	NA	NA	NA	455
1990	NA	NA	NA	727
1991	NA	NA	NA	493

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1992	NA	NA	NA	650
1993	NA	NA	NA	537
1994	NA	NA	NA	688
1995	NA	NA	NA	621
1996	0.10	0.06	565	757
1997	0.10	0.06	623	691
1998	0.08	0.07	792	589
1999	0.07	0.04	643	490
2000	0.10	0.07	723	404
2001	0.09	0.06	647	538
2002	0.12	0.07	613	267
2003	0.10	0.07	731	588
2004	0.08	0.04	512	513
2005	0.08	0.03	321	570
2006	0.16	0.04	272	688
2007	NA	NA	NA	514
2008	0.16	0.07	429	555
2009	0.23	0.14	615	437
2010	0.21	0.11	529	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 28 Annual Area and Production of Isabgol

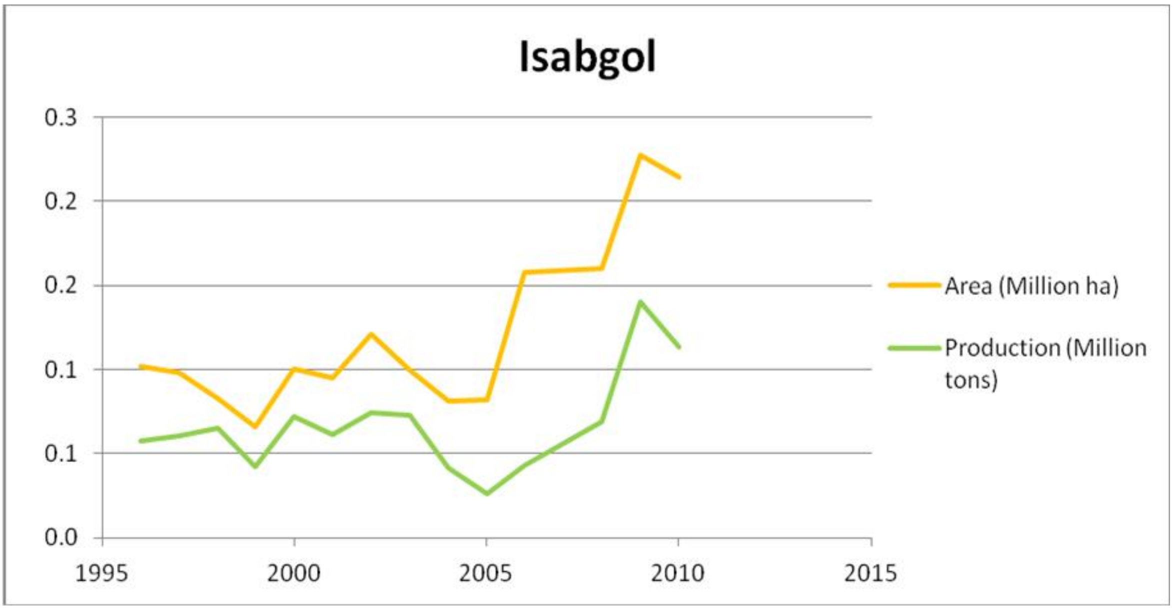
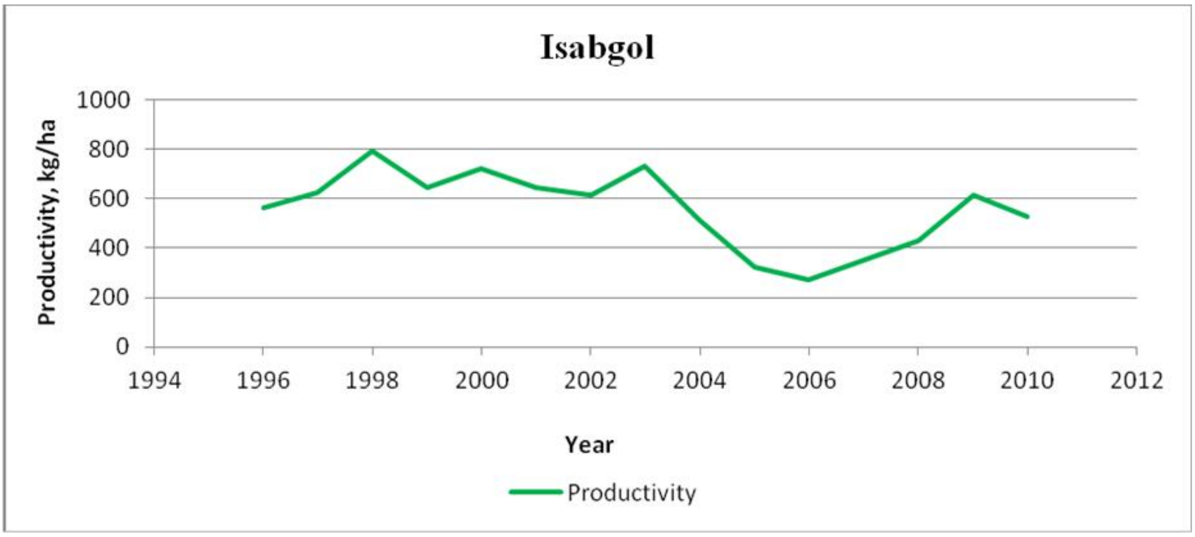


Figure 29 Annual Productivity of Isabgol



Source: Department of Agriculture, Rajasthan, Jaipur

Note: No trials on Isabgol have been carried out at ATCs

Figure 30 Growth Trends in Area and Production of Isabgol

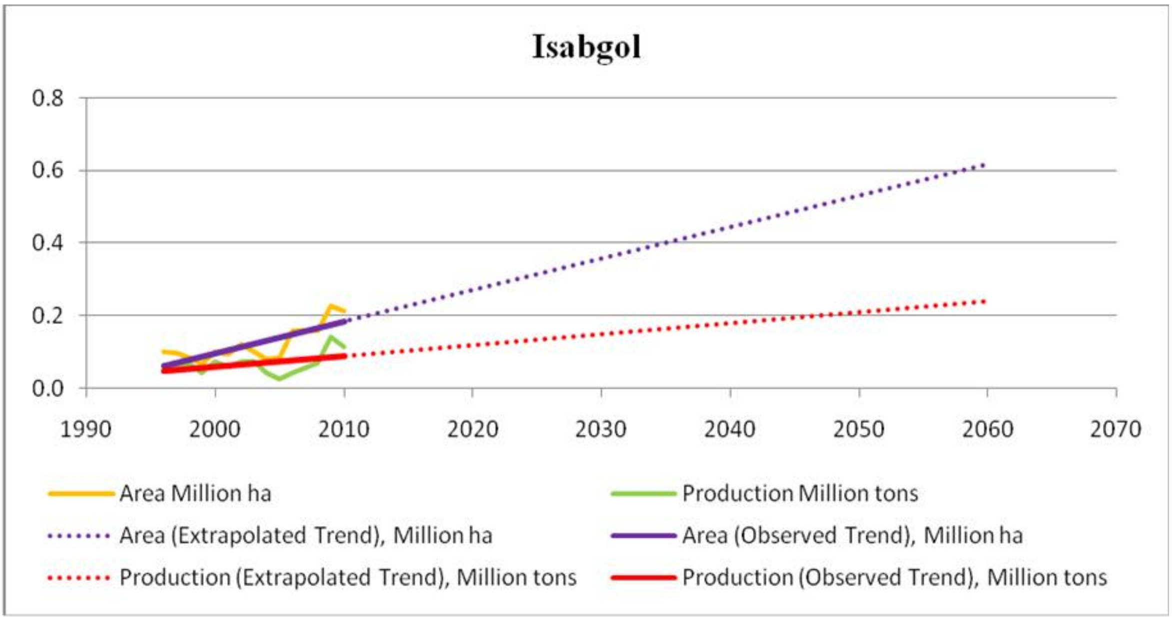


Table 20 Projections of Area Sown, Production and Productivity of Isabgol

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.25	0.14	560
2040	0.40	0.23	575
2060	0.55	0.33	600

1.12 Jowar

Table 21 Area Sown, Production and Productivity of Jowar, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	1.00	0.34	337	427
1981	0.97	0.41	421	562
1982	0.95	0.36	374	560
1983	0.99	0.59	600	621
1984	0.84	0.41	495	475
1985	0.98	0.37	381	503
1986	1.01	0.24	237	464
1987	0.98	0.22	221	315
1988	1.06	0.54	511	534
1989	0.83	0.33	396	455
1990	0.93	0.52	557	727
1991	0.71	0.16	222	493
1992	0.78	0.41	531	650
1993	0.66	0.16	243	537
1994	0.68	0.27	402	688
1995	0.59	0.14	235	621
1996	0.62	0.29	467	757
1997	0.56	0.27	476	691
1998	0.54	0.15	287	589
1999	0.56	0.17	312	490
2000	0.67	0.13	200	404
2001	0.61	0.25	414	538
2002	0.53	0.07	129	267
2003	0.74	0.53	714	588
2004	0.57	0.26	464	513
2005	0.59	0.17	287	570
2006	0.66	0.37	556	688
2007	0.63	0.39	631	514
2008	0.58	0.33	577	555
2009	0.72	0.10	145	437
2010	0.73	0.51	700	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 31 Annual Area and Production of Jowar

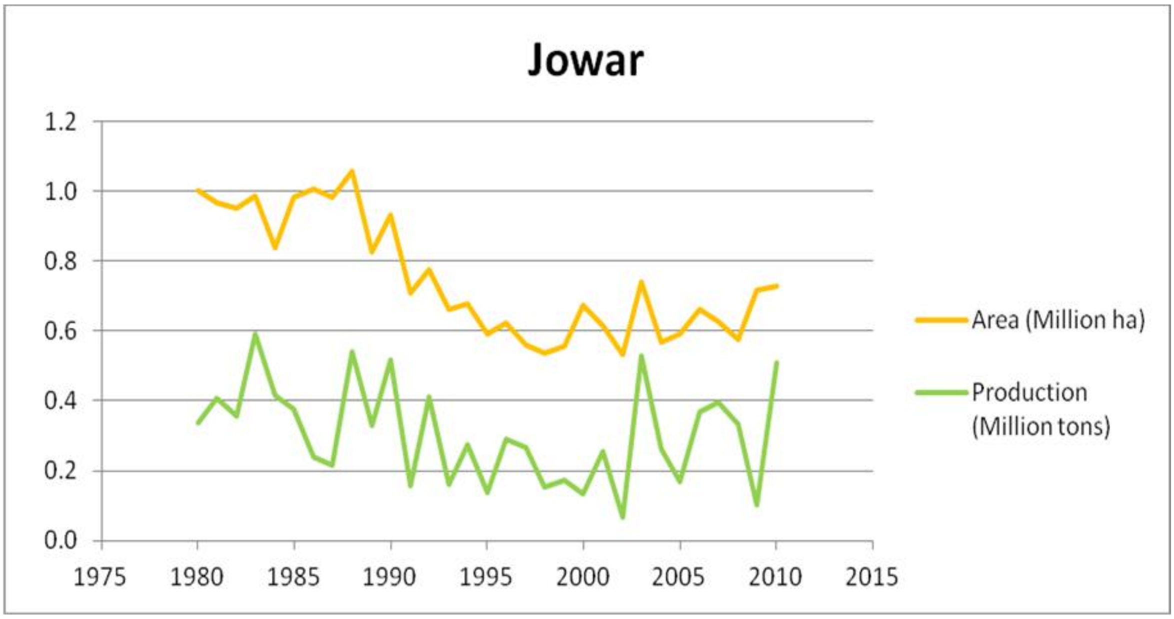
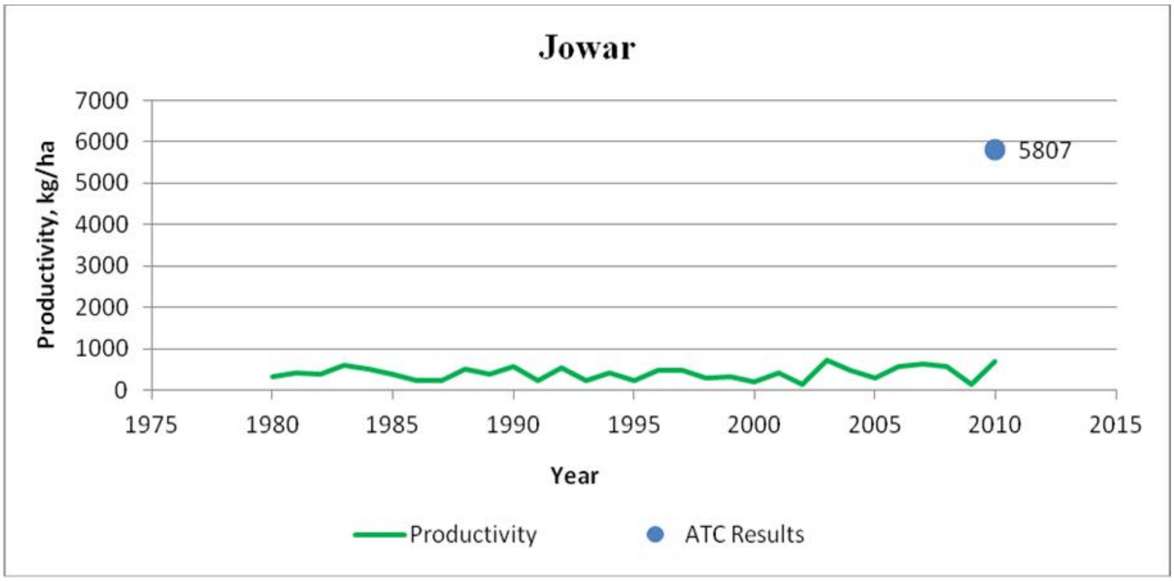


Figure 32 Annual Productivity and ATC Results of Jowar



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 33 Growth Trends in Area and Production of Jowar

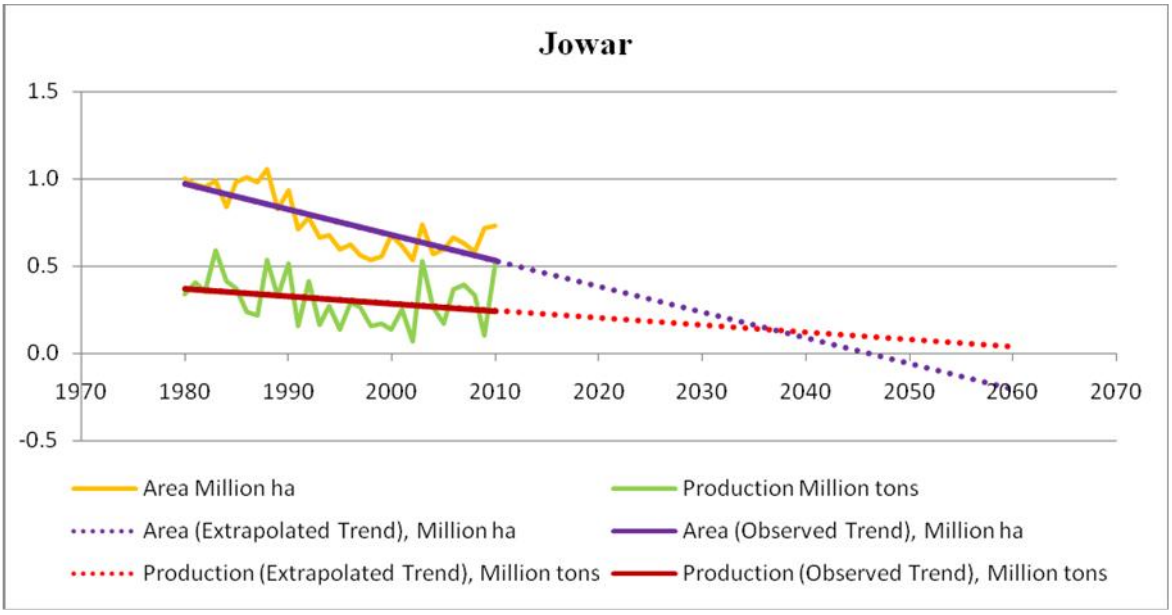


Table 22 Projections of Area Sown, Production and Productivity of Jowar

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.38	0.29	763
2040	0.09	0.07	778
2060	0	0	0

The productivity of Jowar attained in Adaptive Trial Centres (ATC) during the year 2010 was 5,807 kg/ha.

1.13 Maize

Table 23 Area Sown, Production and Productivity of Maize, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.90	0.79	872	427
1981	0.92	0.76	823	562
1982	0.89	0.66	741	560
1983	0.89	1.23	1,376	621
1984	0.91	1.12	1,231	475
1985	0.97	0.64	661	503
1986	0.97	0.65	665	464
1987	0.80	0.30	377	315
1988	0.89	1.22	1,369	534
1989	0.94	1.32	1,394	455
1990	0.98	1.30	1,325	727

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1991	0.95	0.77	808	493
1992	0.95	1.01	1,058	650
1993	0.92	0.92	1,005	537
1994	0.93	0.67	728	688
1995	0.91	0.81	891	621
1996	0.93	1.03	1,109	757
1997	0.97	1.22	1,261	691
1998	0.95	1.02	1,080	589
1999	0.93	0.96	1,033	490
2000	0.97	1.01	1,047	404
2001	1.02	1.48	1,454	538
2002	0.98	0.87	885	267
2003	1.11	2.08	1,869	588
2004	1.04	1.26	1,211	513
2005	1.00	1.10	1,098	570
2006	1.03	1.12	1,083	688
2007	1.05	1.95	1,860	514
2008	1.05	1.83	1,737	555
2009	1.10	1.14	1,044	437
2010	1.14	2.05	1,796	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 34 Annual Area and Production of Maize

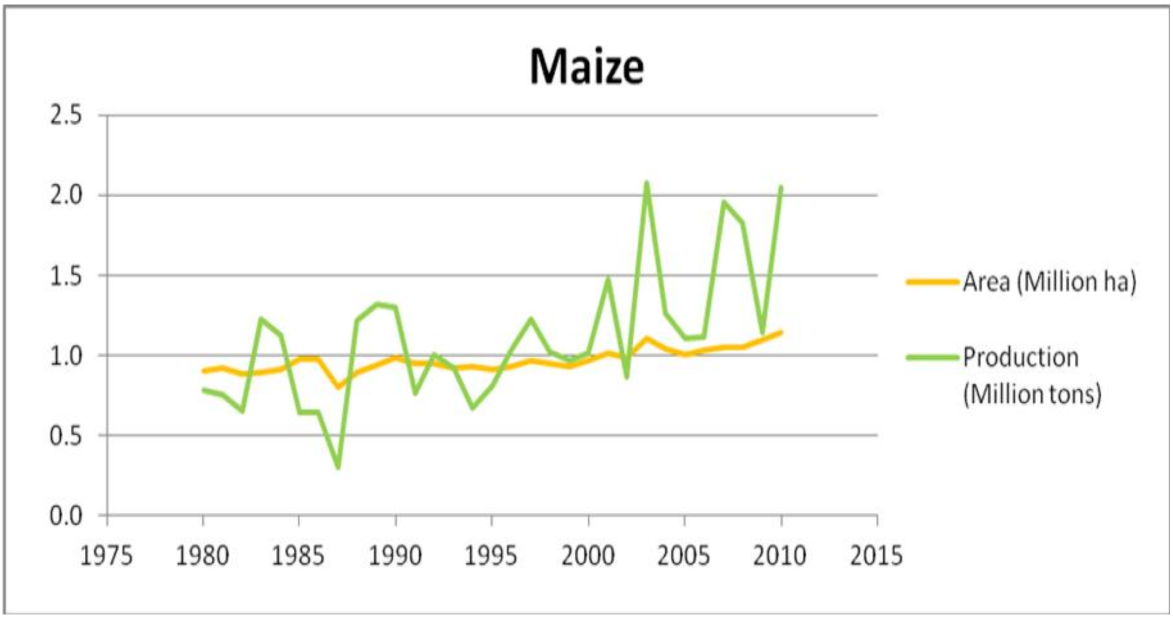
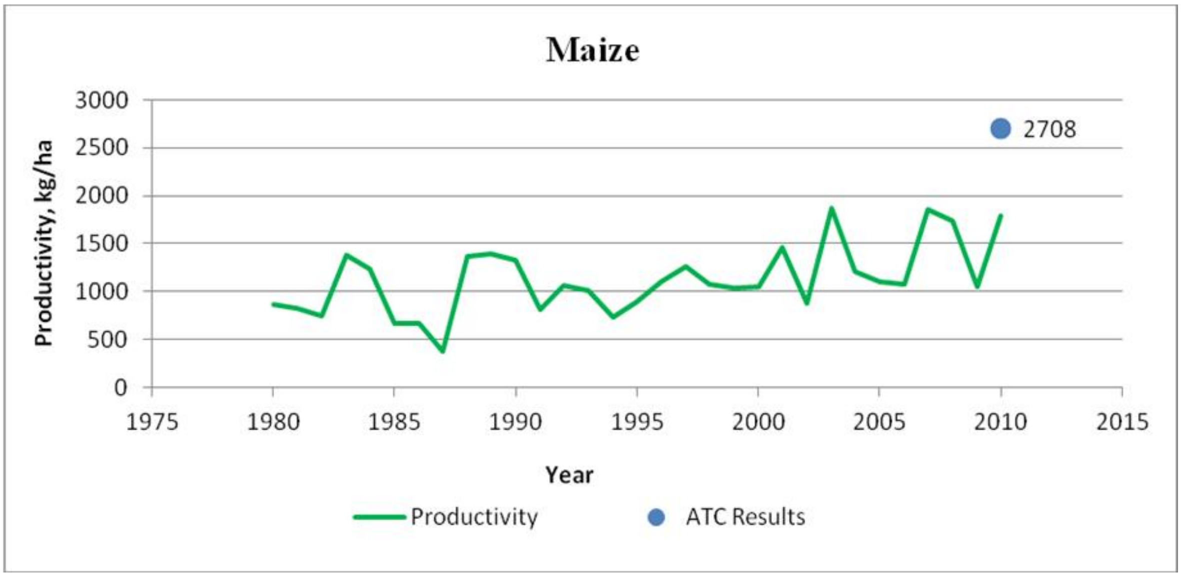


Figure 35 Annual Productivity and ATC Results of Maize



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 36 Growth Trends in Area and Production of Maize

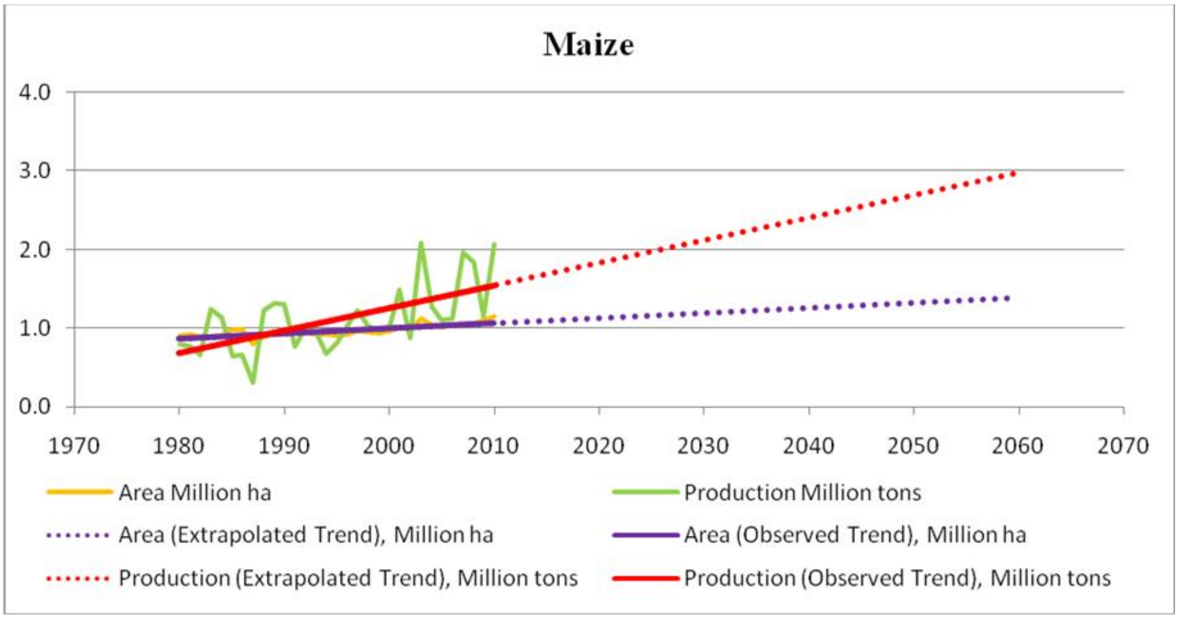


Table 24 Projections of Area Sown, Production and Productivity of Maize

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	1.13	2.07	1,832
2040	1.26	2.62	2,079
2060	1.38	3.47	2,514

The productivity of Maize attained in Adaptive Trial Centres (ATC) during the year 2010 was 2,708 kg/ha.

1.14 Moong

Table 25 Area Sown, Production and Productivity of Moong, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.21	0.05	250	427
1981	0.21	0.03	124	562
1982	0.22	0.02	81	560
1983	0.25	0.09	354	621
1984	0.23	0.05	211	475
1985	0.28	0.02	74	503
1986	0.28	0.02	66	464
1987	0.17	0.01	73	315
1988	0.27	0.12	444	534
1989	0.30	0.08	264	455
1990	0.37	0.13	349	727
1991	0.34	0.04	121	493
1992	0.38	0.15	387	650
1993	0.42	0.05	125	537
1994	0.42	0.13	306	688
1995	0.42	0.08	190	621
1996	0.59	0.24	410	757
1997	0.63	0.16	260	691
1998	0.53	0.06	110	589
1999	0.41	0.04	99	490
2000	0.46	0.08	173	404
2001	0.70	0.21	295	538
2002	0.51	0.03	63	267
2003	0.83	0.51	620	588
2004	0.76	0.21	272	513
2005	0.85	0.14	159	570
2006	0.75	0.27	361	688
2007	1.06	0.42	393	514
2008	0.89	0.37	421	555
2009	0.92	0.04	48	437
2010	1.05	0.65	621	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 37 Annual Area and Production of Moong

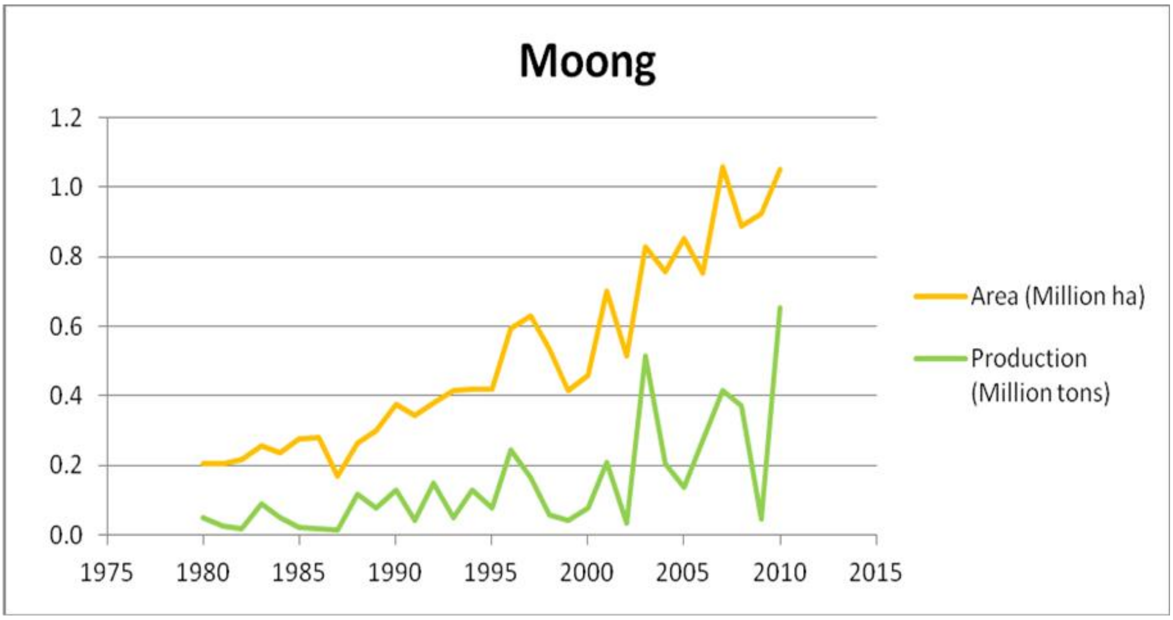
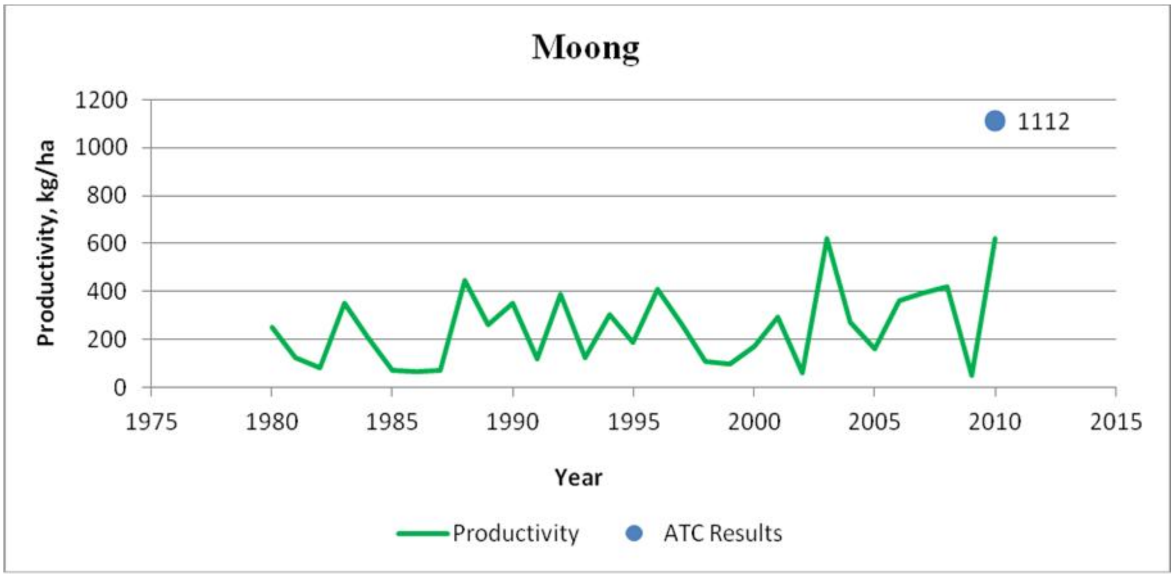


Figure 38 Annual Productivity and ATC Results of Moong



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 39 Growth Trends in Area and Production of Moong

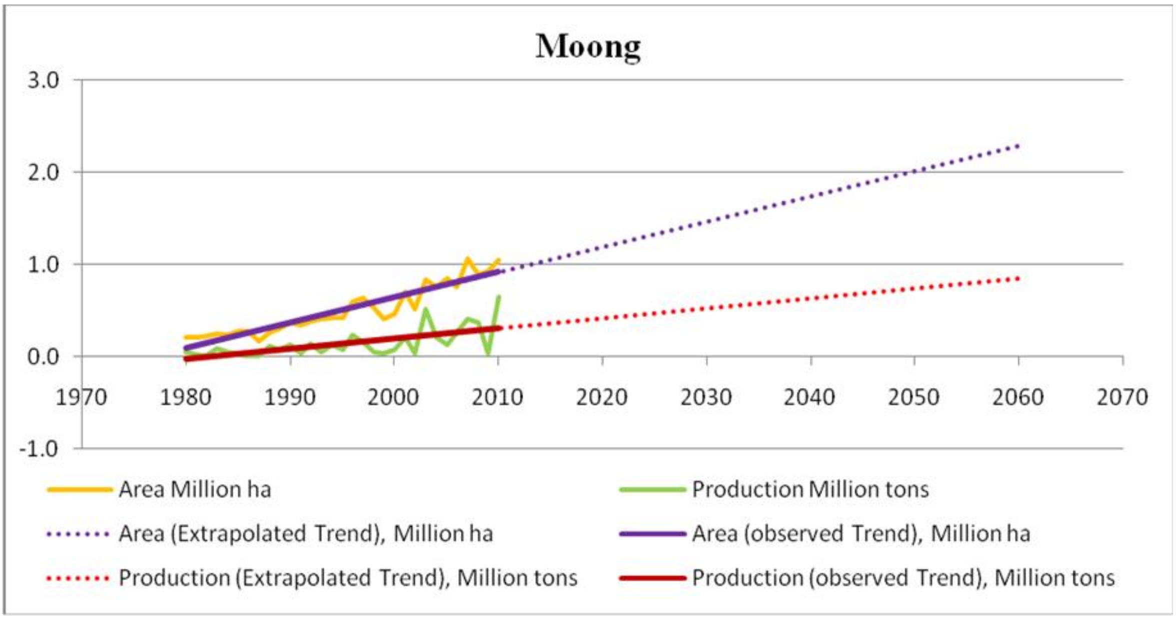


Table 26 Projections of Area Sown, Production and Productivity of Moong

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	1.19	0.76	639
2040	1.74	1.21	695
2060	2.29	1.67	729

The productivity of Moong attained in Adaptive Trial Centres (ATC) during the year 2010 was 1,112 kg/ha

1.15 Moth

Table 27 Area Sown, Production and Productivity of Moth and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	1.33	0.16	121	427
1981	1.26	0.15	117	562
1982	1.21	0.14	119	560
1983	1.28	0.31	247	621
1984	1.22	0.19	157	475
1985	1.25	0.05	39	503
1986	1.15	0.04	37	464
1987	0.72	0.01	10	315
1988	1.12	0.38	344	534
1989	1.21	0.24	199	455
1990	1.34	0.41	304	727

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1991	1.15	0.11	100	493
1992	1.28	0.35	274	650
1993	1.34	0.15	113	537
1994	1.29	0.33	256	688
1995	1.21	0.15	123	621
1996	1.22	0.31	254	757
1997	1.11	0.30	266	691
1998	0.88	0.10	118	589
1999	0.77	0.03	39	490
2000	0.96	0.14	144	404
2001	1.30	0.31	237	538
2002	0.43	0.02	44	267
2003	1.49	0.79	530	588
2004	1.44	0.19	131	513
2005	1.23	0.15	122	570
2006	1.15	0.19	166	688
2007	1.25	0.39	314	514
2008	1.22	0.33	266	555
2009	1.27	0.04	31	437
2010	1.59	0.77	486	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 40 Annual Area and Production of Moth

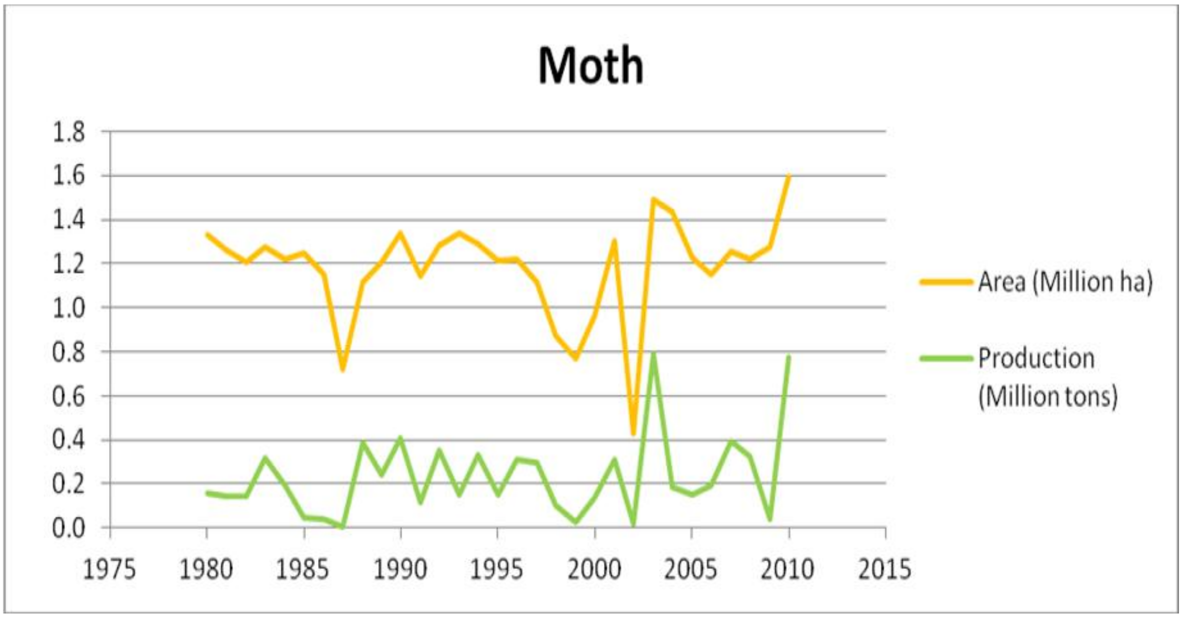
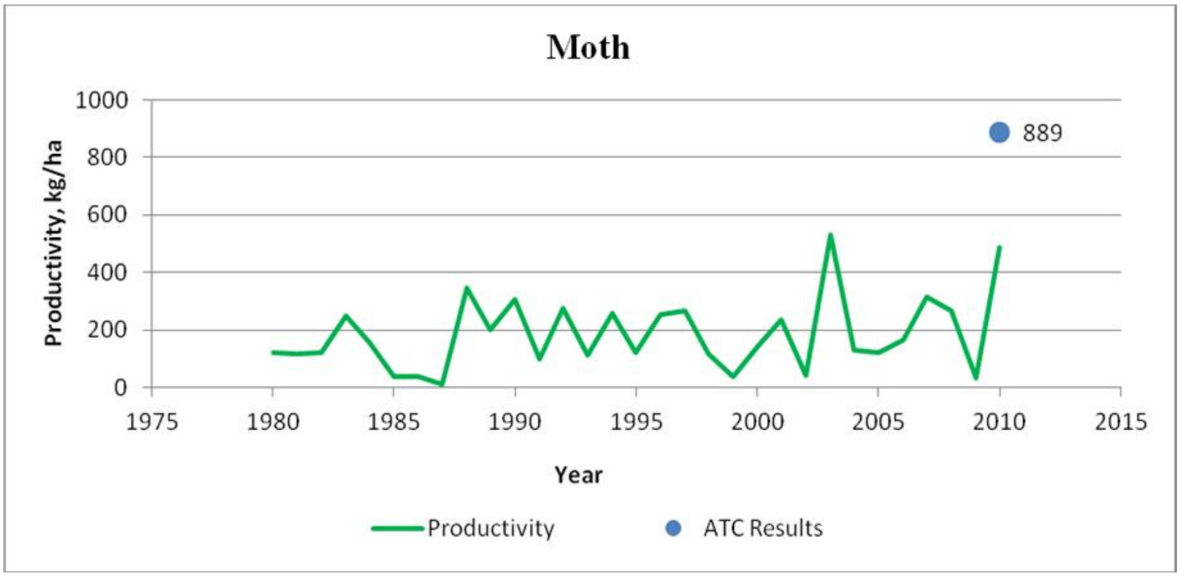


Figure 41 Annual Productivity and ATC Results of Moth



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 42 Growth Trends in Area and Production of Moth

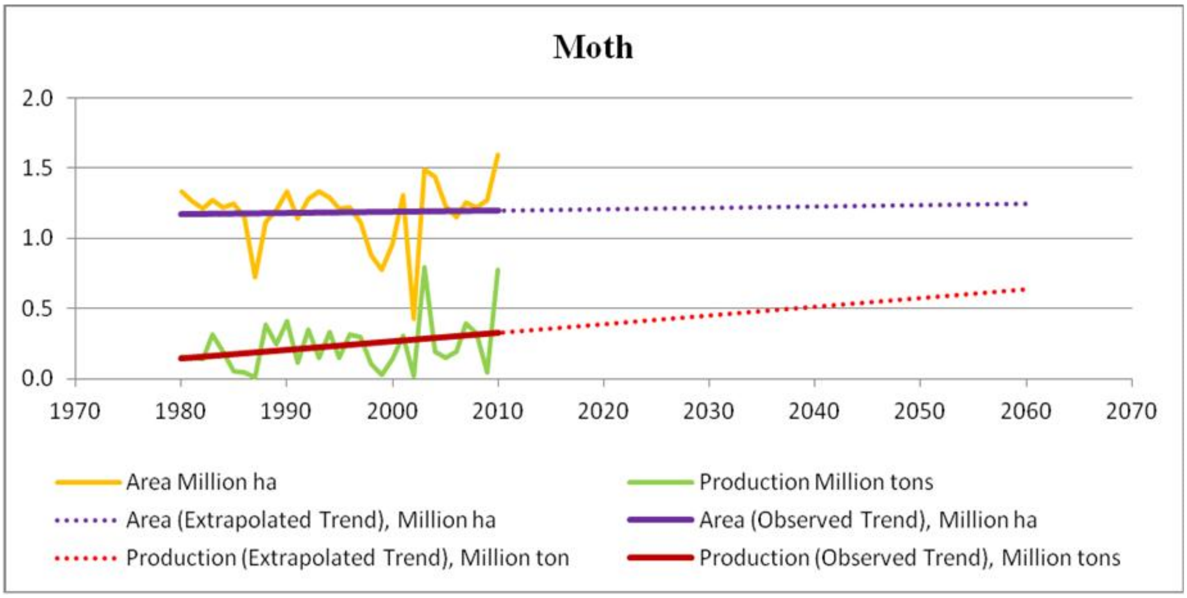


Table 28 Projections of Area Sown, Production and Productivity of Moth

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	1.21	0.63	521
2040	1.23	0.76	618
2060	1.25	0.86	688

The productivity of Moth attained in Adaptive Trial Centres (ATC) during the year 2010 was 889 kg/ha.

1.16 Mustard

Table 29 Area Sown, Production and Productivity of Mustard and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.36	0.25	685	427
1981	0.65	0.46	704	562
1982	0.61	0.44	731	560
1983	0.82	0.65	791	621
1984	1.08	0.87	809	475
1985	0.81	0.59	736	503
1986	0.74	0.66	884	464
1987	1.09	0.93	854	315
1988	1.37	1.35	986	534
1989	1.46	1.28	872	455
1990	1.92	1.67	870	727
1991	2.22	2.13	959	493
1992	2.22	1.72	774	650
1993	2.24	1.65	739	537
1994	2.27	2.02	887	688
1995	2.69	2.37	880	621
1996	2.62	2.62	1,002	757
1997	2.81	2.04	726	691
1998	2.32	2.23	962	589
1999	2.50	2.46	986	490
2000	1.40	1.30	929	404
2001	1.76	1.91	1,084	538
2002	1.19	1.18	989	267
2003	2.06	2.69	1,306	588
2004	3.29	3.86	1,174	513
2005	3.56	4.39	1,232	570
2006	3.10	3.77	1,215	688
2007	NA	NA	NA	514
2008	2.74	3.47	1,266	555
2009	2.21	2.91	1,316	437
2010	2.49	3.88	1,560	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 43 Annual Area and Production of Mustard

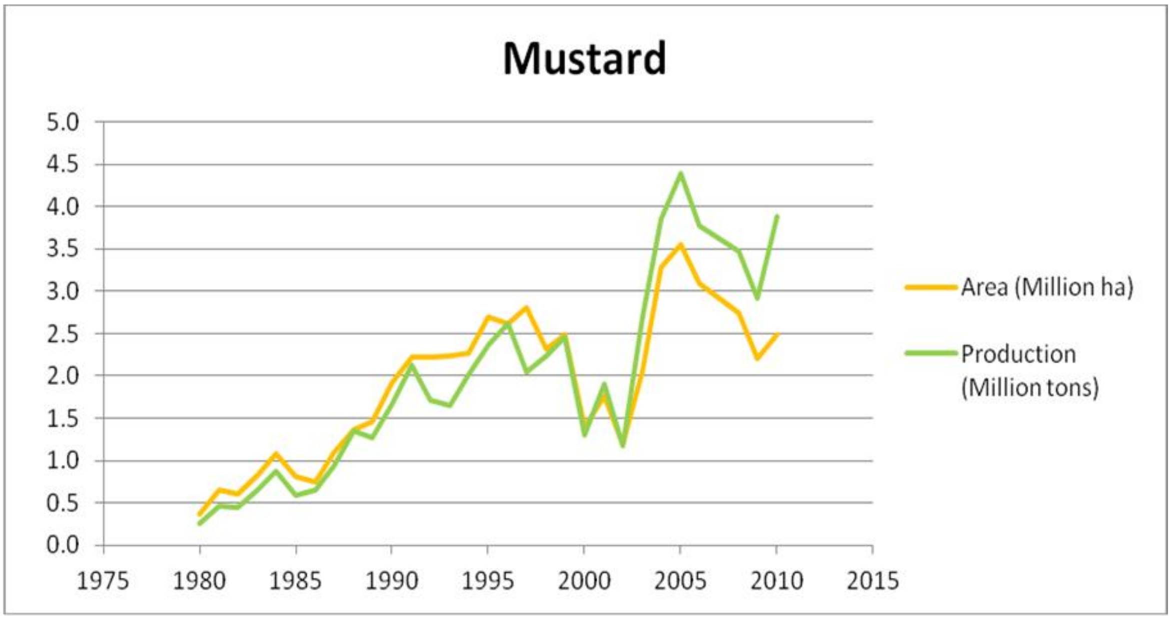
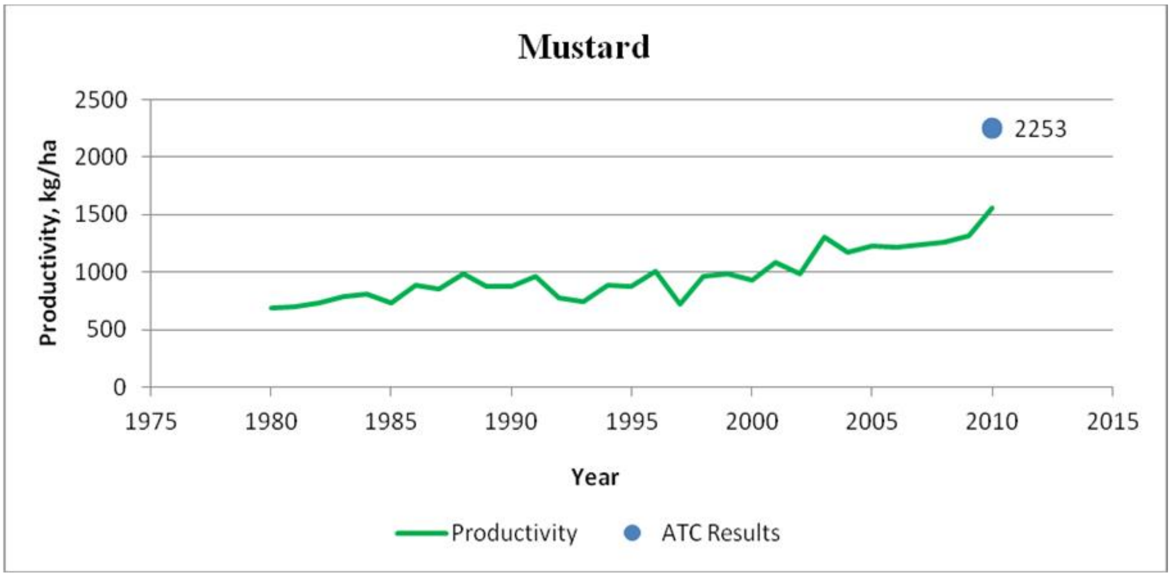


Figure 44 Annual Productivity and ATC Results of Mustard



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 45 Growth Trends in Area and Production of Mustard

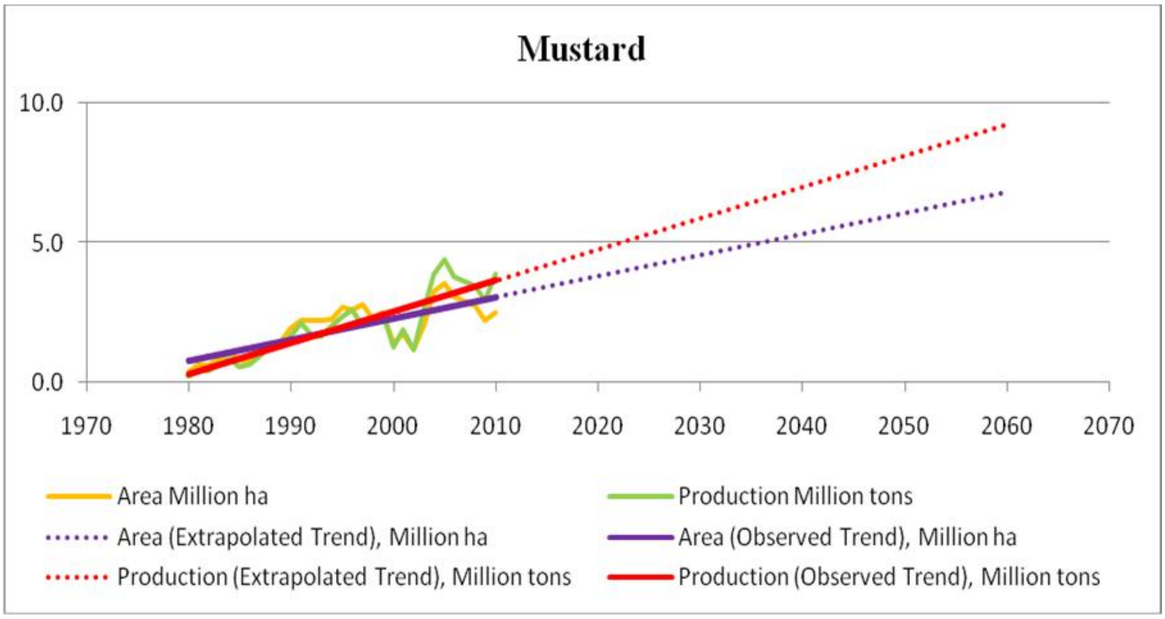


Table 30 Projections of Area Sown, Production and Productivity of Mustard

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	3.80	5.96	1,568
2050	6.06	12.85	2,120
2060	6.81	15.87	2,330

The productivity of Mustard attained in Adaptive Trial Centres (ATC) during the year 2010 was 2,253 kg/ha.

1.17 Rice

Table 31 Area Sown, Production and Productivity of Rice, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.17	0.15	881	427
1981	0.14	0.14	991	562
1982	0.12	0.09	740	560
1983	0.16	0.22	1,358	621
1984	0.17	0.21	1,252	475
1985	0.13	0.12	909	503
1986	0.15	0.13	881	464
1987	0.10	0.05	495	315
1988	0.13	0.19	1,421	534
1989	0.12	0.15	1,270	455
1990	0.12	0.14	1,183	727
1991	0.14	0.12	852	493

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1992	0.14	0.17	1,234	650
1993	0.14	0.14	1,017	537
1994	0.16	0.17	1,089	688
1995	0.14	0.12	843	621
1996	0.15	0.17	1,185	757
1997	0.16	0.19	1,164	691
1998	0.17	0.21	1,223	589
1999	0.20	0.25	1,261	490
2000	0.17	0.16	937	404
2001	0.14	0.18	1,247	538
2002	0.08	0.07	813	267
2003	0.10	0.16	1,653	588
2004	0.10	0.15	1,484	513
2005	0.11	0.15	1,424	570
2006	0.11	0.17	1,576	688
2007	0.13	0.26	2,031	514
2008	0.13	0.24	1,807	555
2009	0.15	0.23	1,515	437
2010	0.13	0.27	2,025	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 46 Annual Area and Production of Rice

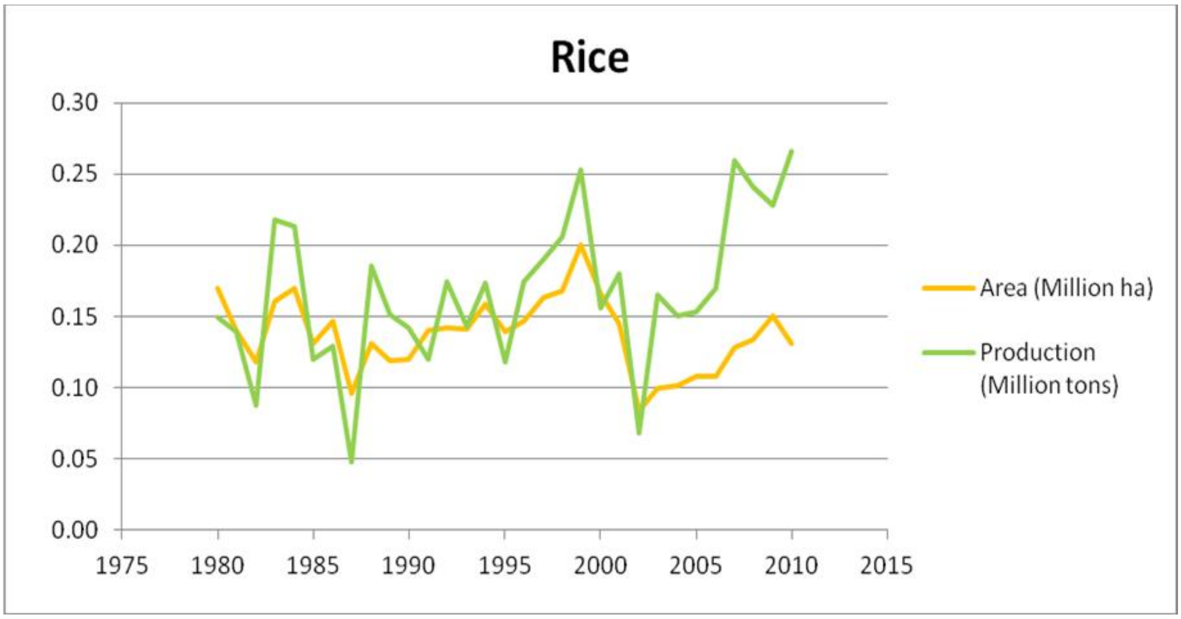
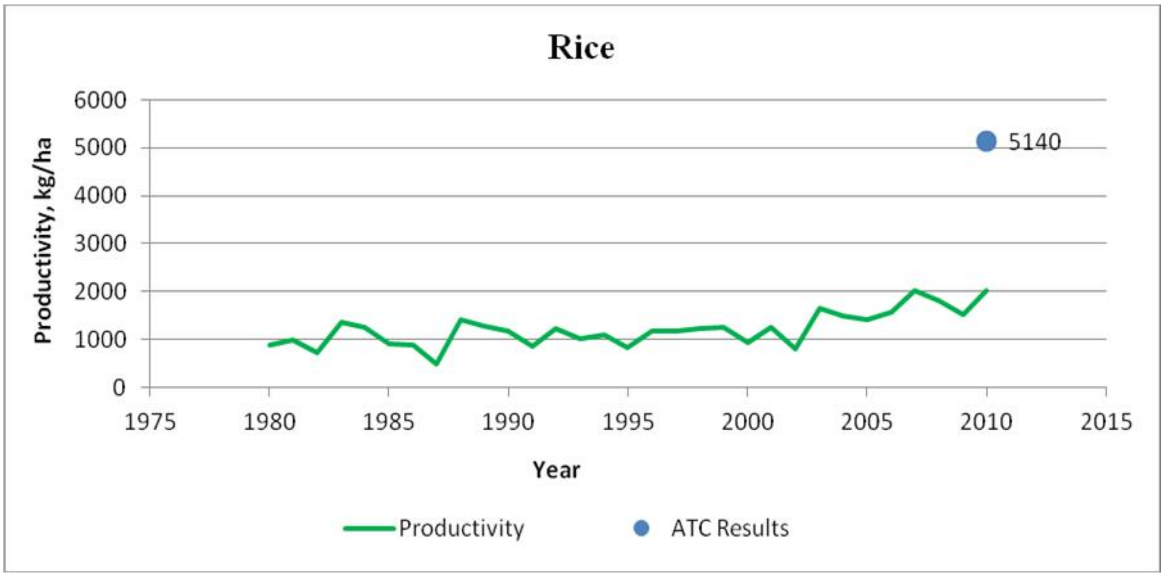


Figure 47 Annual Productivity and ATC Results of Rice



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 48 Growth Trends in Area and Production of Rice

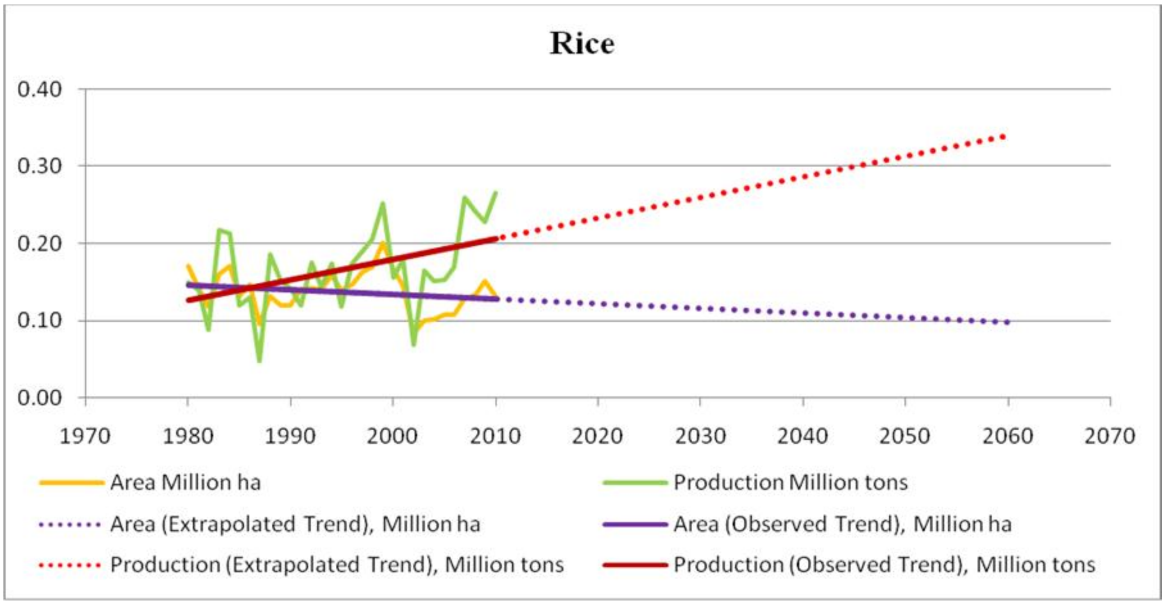


Table 32 Projections of Area Sown, Production and Productivity of Rice

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.12	0.26	2,167
2040	0.11	0.29	2,636
2060	0.10	0.34	3,400

The productivity of Rice attained in Adaptive Trial Centres (ATC) during the year 2010 was 5,140 kg/ha.

1.18 Sesamum

Table 33 Area Sown, Production and Productivity of Sesamum and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.43	0.03	79	427
1981	0.43	0.05	116	562
1982	0.45	0.04	91	560
1983	0.38	0.07	173	621
1984	0.42	0.07	175	475
1985	0.52	0.03	52	503
1986	0.34	0.01	20	464
1987	0.21	0.01	44	315
1988	0.32	0.06	191	534
1989	0.44	0.13	287	455
1990	0.58	0.19	323	727
1991	0.69	0.12	170	493
1992	0.45	0.10	229	650
1993	0.52	0.05	103	537
1994	0.41	0.09	227	688
1995	0.33	0.03	104	621
1996	0.42	0.09	209	757
1997	0.27	0.05	197	691
1998	0.24	0.02	73	589
1999	0.21	0.02	74	490
2000	0.23	0.03	138	404
2001	0.32	0.10	327	538
2002	0.19	0.01	60	267
2003	0.31	0.14	453	588
2004	0.45	0.15	333	513
2005	0.42	0.06	149	570
2006	0.26	0.09	335	688
2007	0.31	0.13	403	514
2008	0.52	0.15	293	555
2009	0.60	0.10	163	437
2010	0.55	0.22	408	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 49 Annual Area and Production of Sesamum

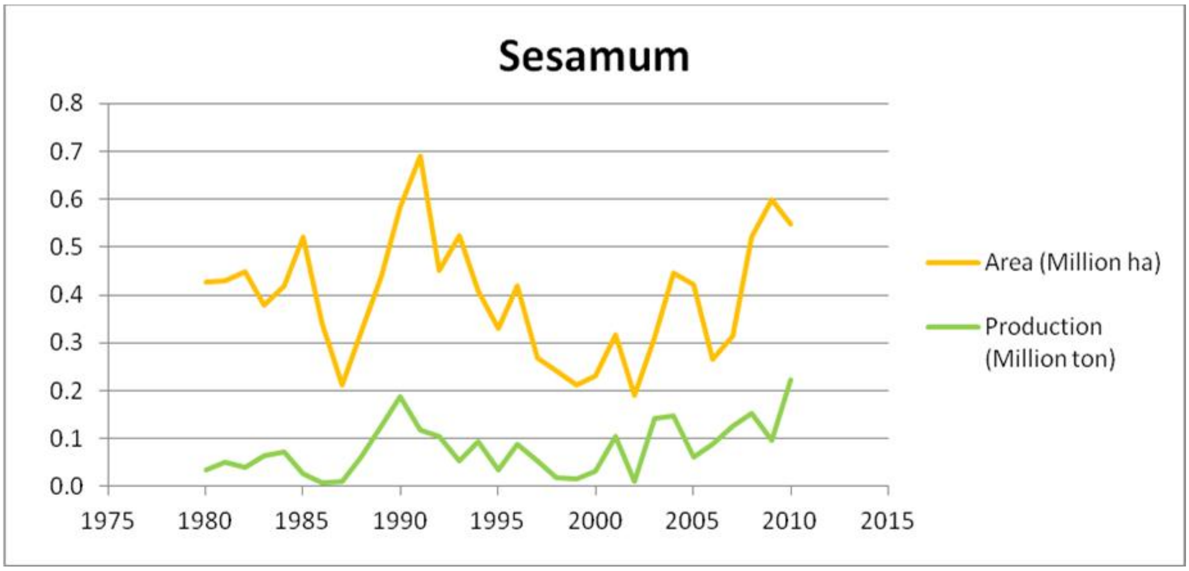
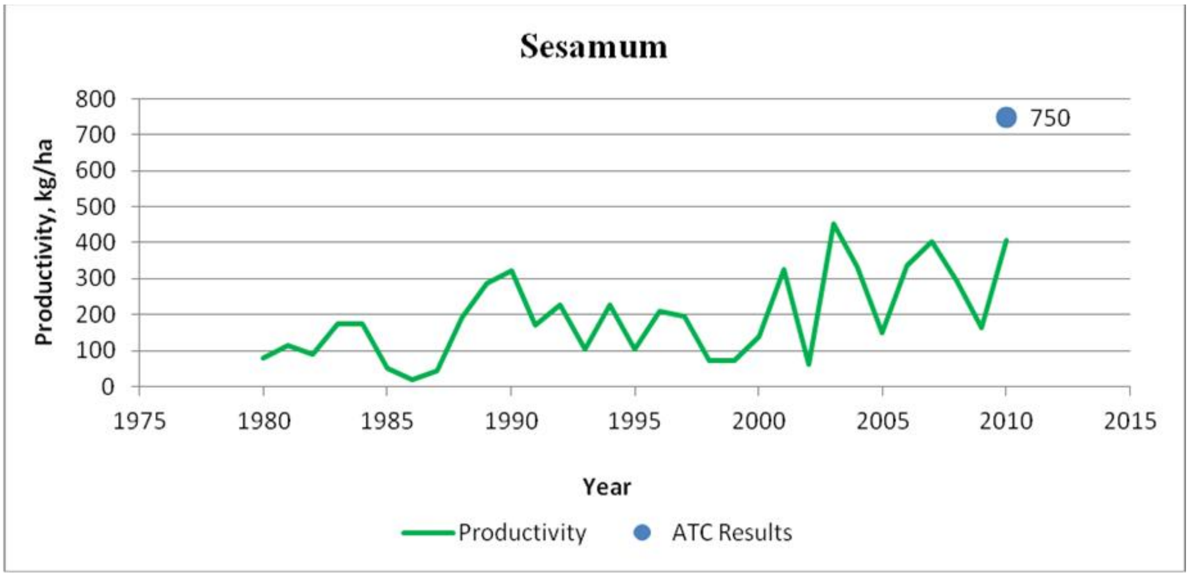


Figure 50 Annual Productivity and ATC Results of Sesamum



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 51 Growth Trends in Area and Production of Sesamum

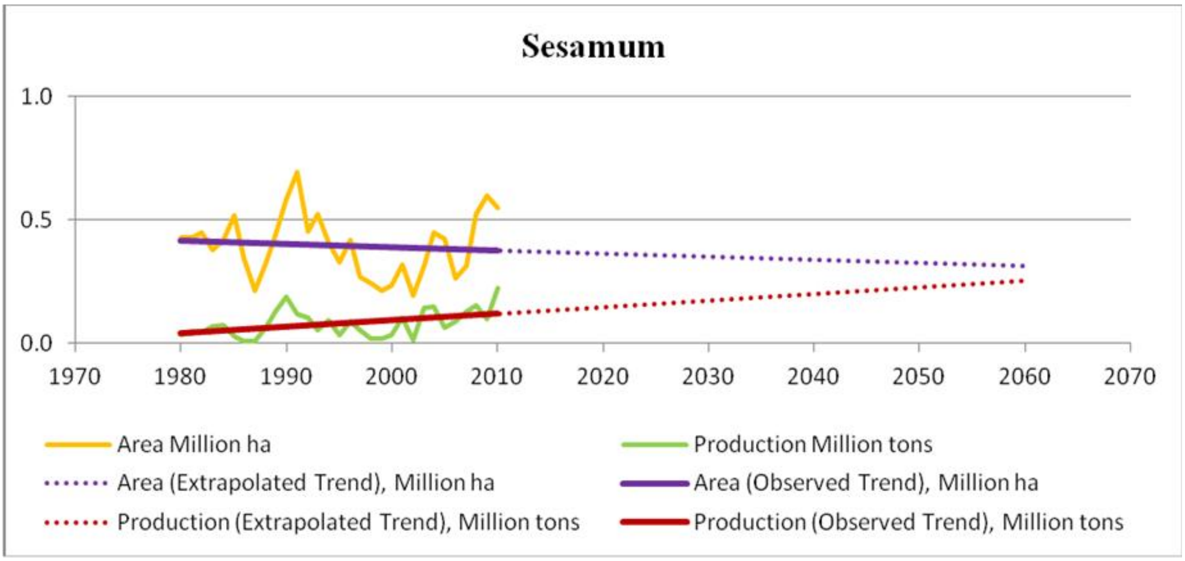


Table 34 Projections of Area Sown, Production and Productivity of Sesamum

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.36	0.16	444
2040	0.34	0.20	588
2060	0.31	0.25	806

The productivity of Sesamum attained in Adaptive Trial Centres (ATC) during the year 2010 was 750 kg/ha

1.19 Soyabean

Table 35 Area Sown, Production and Productivity of Soyabean and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	NA	NA	NA	427
1981	NA	NA	NA	562
1982	NA	NA	NA	560
1983	0.02	0.02	688	621
1984	0.03	0.03	855	475
1985	0.04	0.03	745	503
1986	0.05	0.04	754	464
1987	0.08	0.06	734	315
1988	0.11	0.12	1,156	534
1989	0.17	0.14	800	455
1990	0.14	0.16	1,113	727
1991	0.17	0.13	757	493
1992	0.26	0.33	1,259	650

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1993	0.35	0.37	1,070	537
1994	0.40	0.44	1,098	688
1995	0.43	0.40	937	621
1996	0.47	0.45	975	757
1997	0.50	0.63	1,265	691
1998	0.68	0.89	1,315	589
1999	0.49	0.60	1,221	490
2000	0.66	0.46	691	404
2001	0.66	0.72	1,091	538
2002	0.47	0.24	501	267
2003	0.49	0.69	1,400	588
2004	0.62	0.89	1,425	513
2005	0.74	0.86	1,150	570
2006	0.64	0.77	1,203	688
2007	0.80	1.07	1,343	514
2008	0.83	0.81	974	555
2009	0.78	0.91	1,175	437
2010	0.77	1.12	1,461	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 52 Annual Area and Production of Soyabean

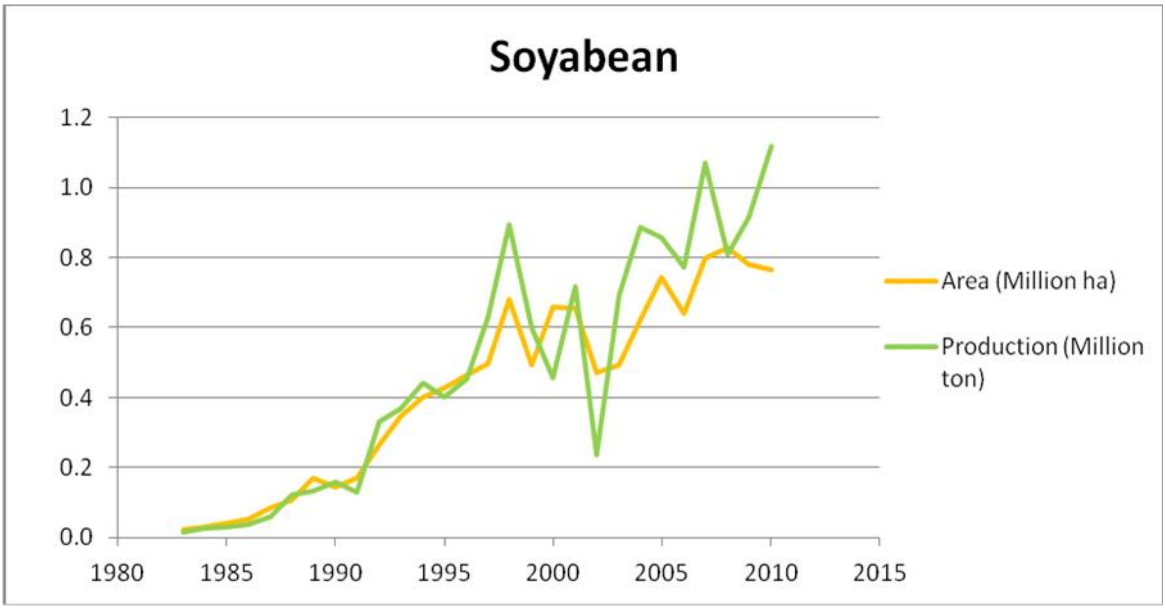
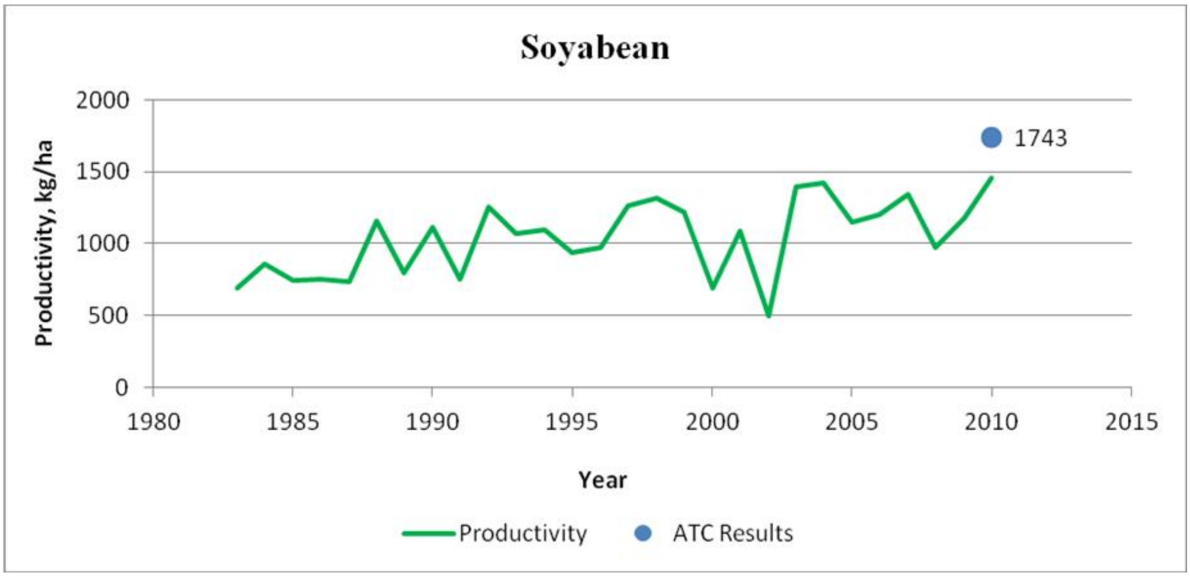


Figure 53 Annual Productivity and ATC Results of Soyabean



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 54 Growth Trends in Area and Production of Soyabean

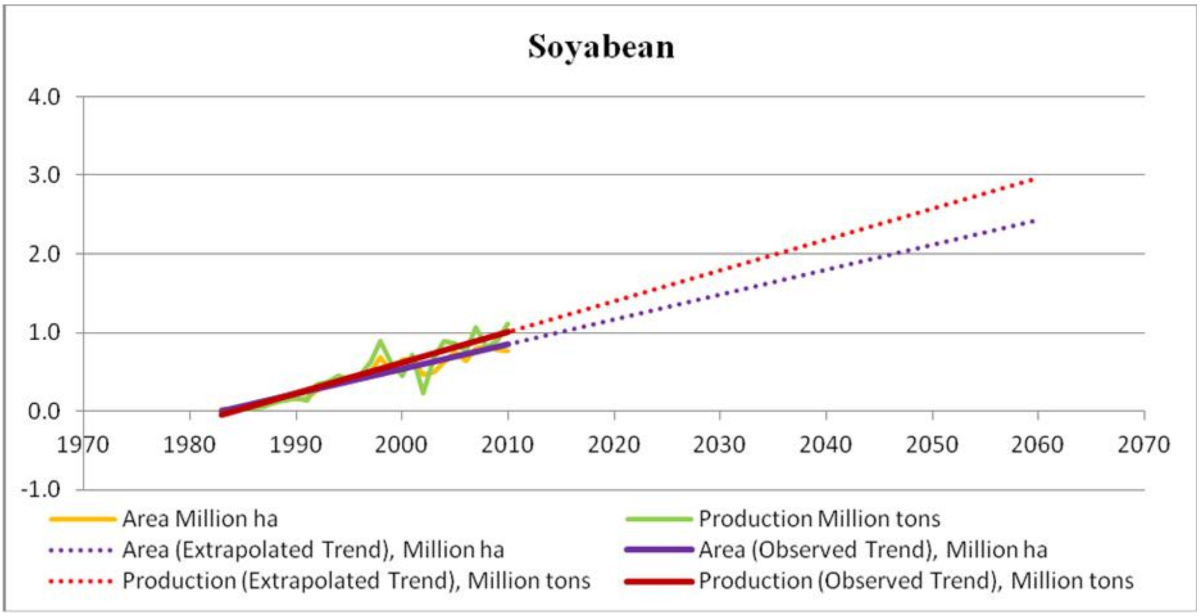


Table 36 Projections of Area Sown, Production and Productivity of Soyabean

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	1.17	1.74	1,487
2040	1.80	3.23	1,794
2060	2.43	5.21	2,144

The productivity of Soyabean attained in Adaptive Trial Centres (ATC) during the year 2010 was 1,743 kg/ha

1.20 Urad

Table 37 Area Sown, Production and Productivity of Urad, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	0.16	0.06	395	427
1981	0.16	0.05	346	562
1982	0.14	0.05	333	560
1983	0.16	0.09	556	621
1984	0.16	0.08	482	475
1985	0.18	0.02	113	503
1986	0.19	0.02	113	464
1987	0.12	0.02	131	315
1988	0.14	0.07	488	534
1989	0.14	0.05	364	455
1990	0.15	0.06	360	727
1991	0.15	0.03	232	493
1992	0.16	0.06	398	650
1993	0.18	0.06	302	537
1994	0.15	0.04	256	688
1995	0.15	0.06	418	621
1996	0.20	0.07	356	757
1997	0.21	0.10	466	691
1998	0.17	0.05	318	589
1999	0.12	0.03	283	490
2000	0.11	0.03	288	404
2001	0.18	0.07	362	538
2002	0.26	0.05	182	267
2003	0.24	0.13	522	588
2004	0.15	0.05	360	513
2005	0.13	0.03	246	570
2006	0.11	0.03	293	688
2007	0.14	0.08	530	514
2008	0.14	0.04	296	555
2009	0.12	0.03	263	437
2010	0.13	0.09	737	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 55 Annual Area and Production of Urad

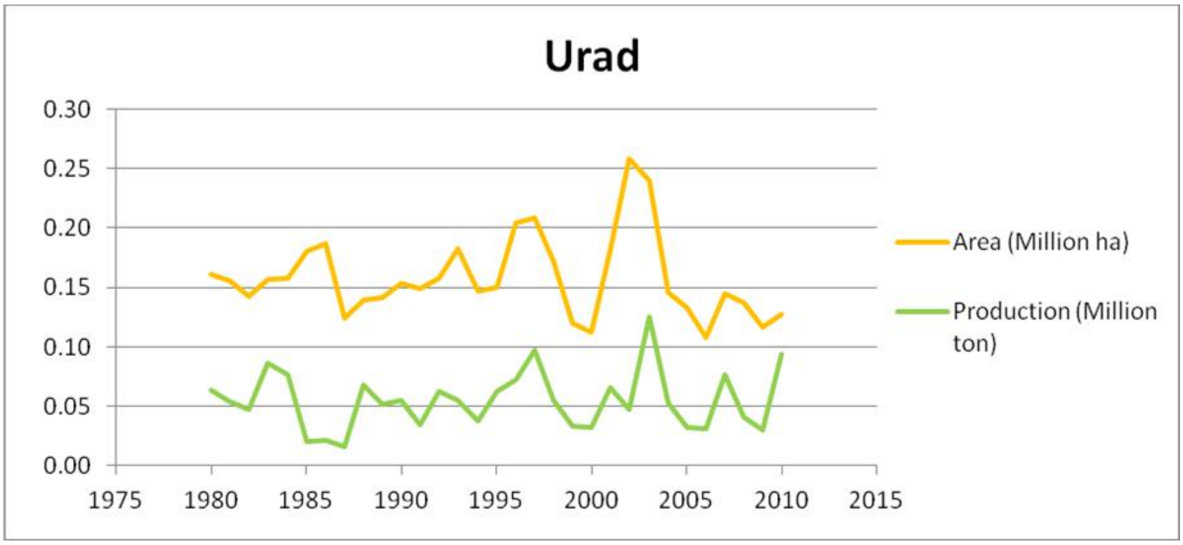
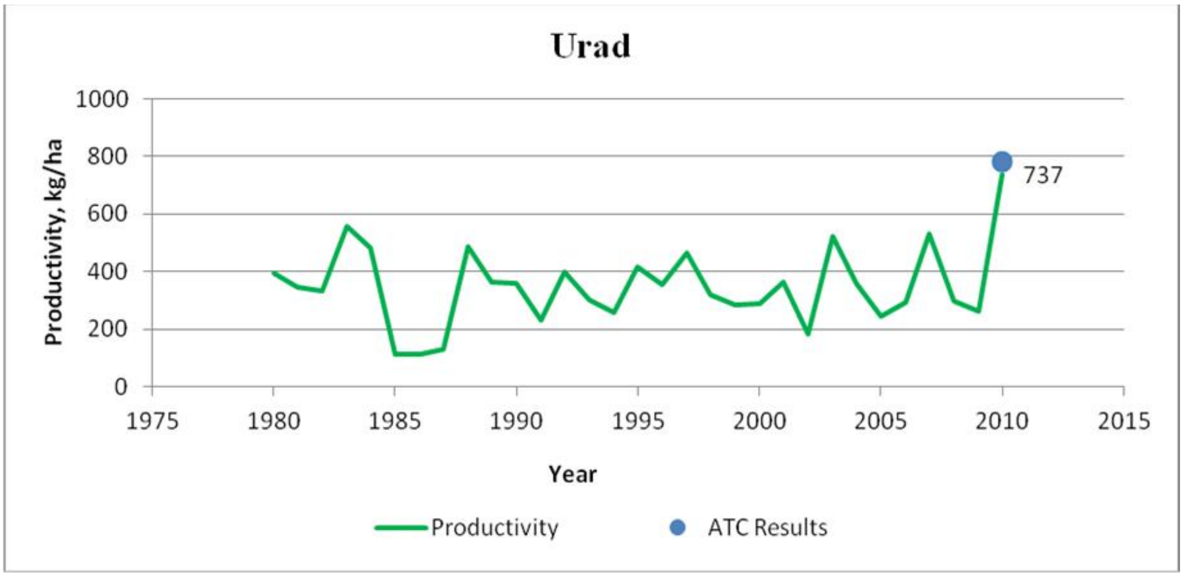


Figure 56 Annual Productivity and ATC Results Productivity of Urad



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 57 Growth Trends in Area and Production of Urad

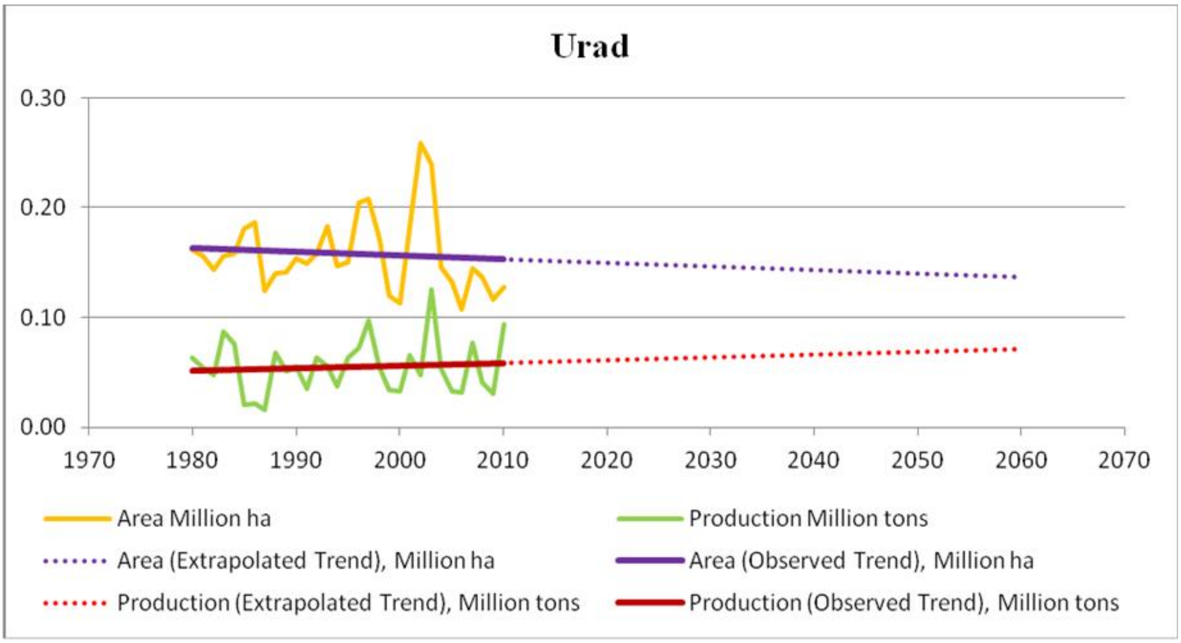


Table 38 Projections of Area Sown, Production and Productivity of Urad

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	0.15	0.06	400
2040	0.14	0.08	571
2060	0.13	0.09	692

The productivity of Urad attained at Adaptive Trial Centres (ATC) during the year 2010 was 783 kg/ha

1.21 Wheat

Table 39 Area Sown, Production and Productivity of Wheat, and Rainfall

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1980	1.64	2.39	1,464	427
1981	1.77	2.93	1,659	562
1982	2.07	3.79	1,830	560
1983	2.16	3.44	1,594	621
1984	1.72	2.79	1,625	475
1985	1.68	3.72	2,219	503
1986	1.84	3.40	1,845	464
1987	1.53	2.91	1,897	315
1988	1.77	3.96	2,240	534
1989	1.65	3.40	2,060	455

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha	Rainfall, mm
1990	1.81	4.31	2,375	727
1991	1.78	4.48	2,517	493
1992	2.25	5.15	2,287	650
1993	2.01	3.46	1,719	537
1994	2.32	5.61	2,417	688
1995	2.20	5.49	2,501	621
1996	2.47	6.78	2,741	757
1997	2.68	6.70	2,500	691
1998	2.77	6.88	2,487	589
1999	2.65	6.73	2,540	490
2000	2.31	5.55	2,405	404
2001	2.29	6.39	2,793	538
2002	1.80	4.88	2,709	267
2003	2.10	5.88	2,794	588
2004	2.01	5.71	2,839	513
2005	2.12	5.87	2,762	570
2006	2.56	7.76	3,024	688
2007	NA	NA	NA	514
2008	2.29	7.29	3,175	555
2009	2.39	7.50	3,133	437
2010	3.04	10.42	3,433	684

Source: Department of Agriculture, Rajasthan, Jaipur

Figure 58 Annual Area and Production of Wheat

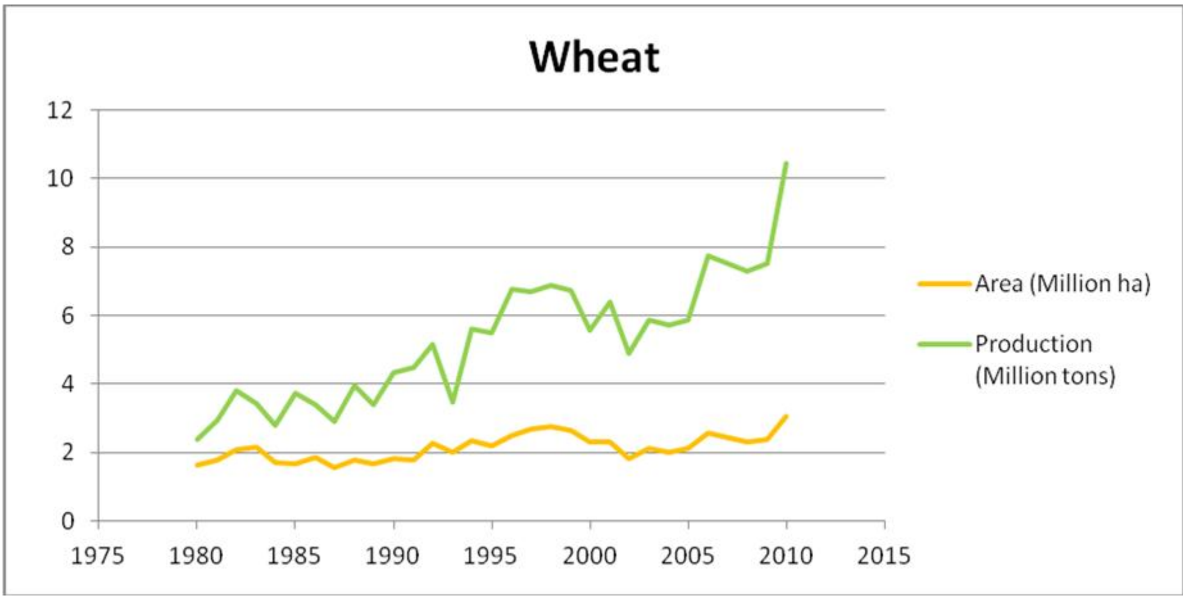
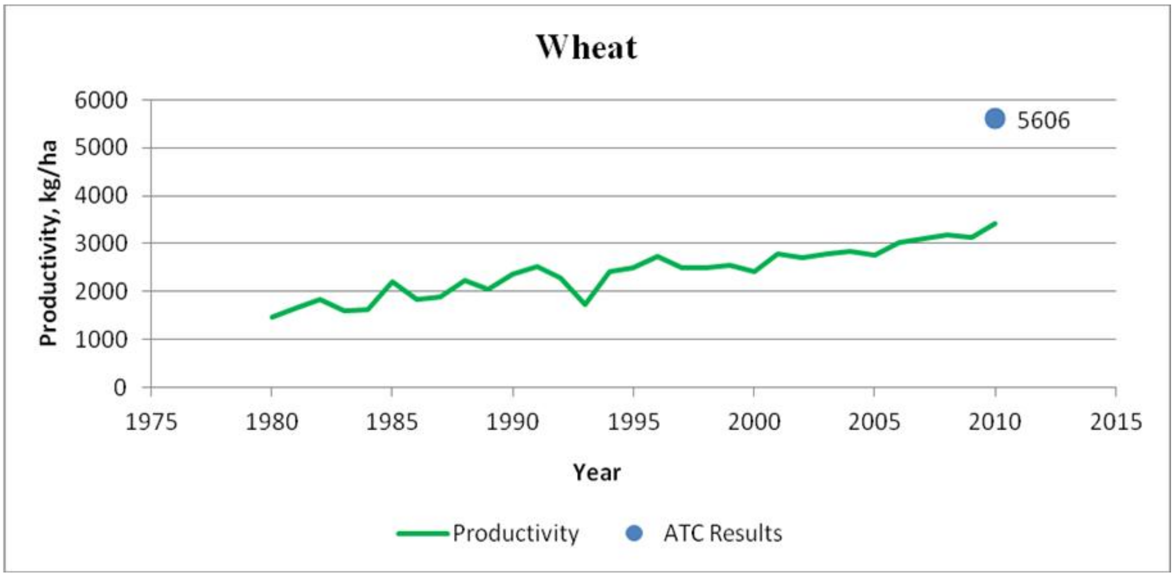


Figure 59 Annual Productivity and ATC Results of Wheat



Source: Department of Agriculture, Rajasthan, Jaipur

Figure 60 Growth Trends in Area and Production of Wheat

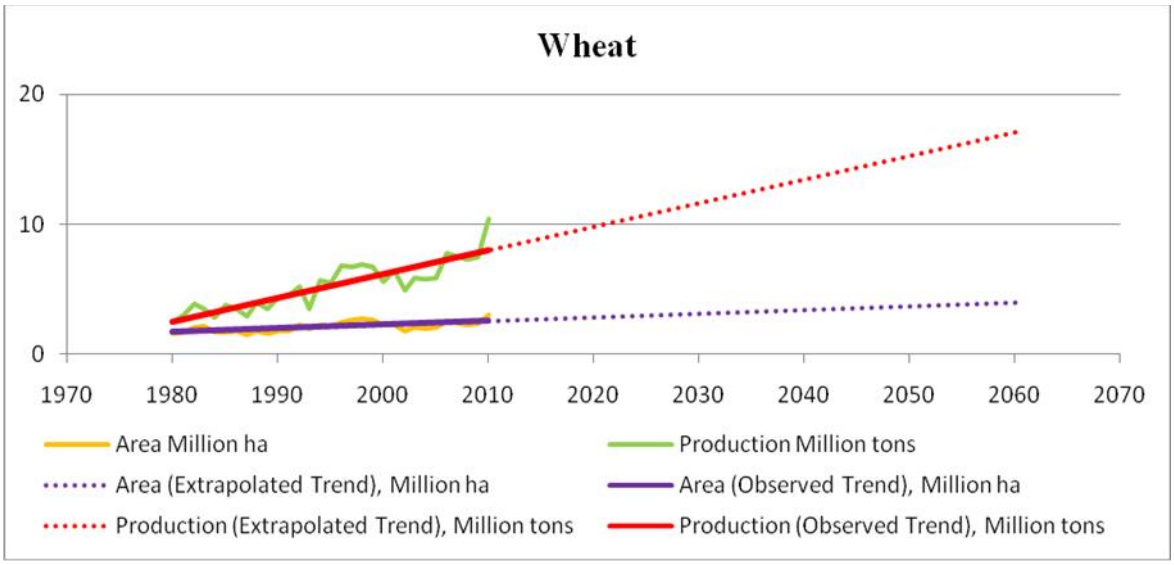


Table 40 Projections of Area Sown, Production and Productivity of Wheat

Year	Area Sown, Million ha	Production, Million tons	Productivity, kg/ha
2020	2.83	9.80	3,463
2040	3.39	13.44	3,965
2060	3.95	17.07	4,322

The productivity of Wheat attained in Adaptive Trial Centres (ATC) during the year 2010 was 5,606 kg/ha.

Appendix 15
Visited Hydro-Meteorological Stations – Findings and Photos

a. Rainfall Stations

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
Tonk WRD	Banas	Tonk	133	26°10´00"	75°48´00"	3/3/2011	Daily rainfall station positioned on ground level, disturbed by vegetation to be cut.
Sri Mahavirji WRD	Gambhir	Karauli	240	26°42´00"	76°55´00"	25/5/2011	Rain recorder positioned about 50 cm above ground level and daily rainfall gauge positioned on ground level. The rain recorder is attached to a data logger disturbed by vegetation to be cut.
Chhaparwara WRD	Banas	Jaipur	165	26°39´00"	75°14´00"	26/5/2011	Daily rainfall station positioned at ground level.
Kanota WRD	Banas	Jaipur	186	26°53´00"	75°56´00"	1/3/2011	Daily rainfall and rain recorder measurement facilities. The rain recorder is not functioning since 2007 due to maintenance problems. The house where the nearby weather station is located may be an obstacle. The rain gauge station should be moved.
Lalsot Irrigation Colony	Banas	Dausa	187	26°33´00"	76°20´00"	25/5/2011	Rain recorder and daily rainfall measurement facilities positioned on the roof of a 1 story building. The rain recorder is attached to a data logger.
Lalsot Tehsil WRD	Banas	Dausa	-	26°33´00"	76°20´00"	25/5/2011	Daily rainfall station positioned on the roof of a 2 stories building disturbed by vegetation to be cut...
Morel Dam WRD	Banas	Dausa	406	26°27´00"	76°22´00"	25/5/2011	Daily rainfall station positioned on the roof of a 1 story building.
Ramgarh Dam WRD	Banganga	Jaipur	225	27°04´00"	76°02´00"	31/5/2011	Daily rainfall station on the dam crest.
Shahpura Tehsil	Banganga	Bhilwara	150	27°23´00"	75°58´00"	31/5/2011	Daily rainfall station positioned on the roof of a 1 story building
Malakhera Tehsil	Ruparail	Alwar	247	27°24´00"	76°37´00"	31/5/2011	Daily rainfall station positioned on the roof of a 1 story building. Rain recorder damaged.
Jaipur (2)	Banas	Jaipur	184	26°55´00"	75°50´00"	2/6/2011	Daily rainfall station and temperature measurements positioned on the ground disturbed by nearby high building to be moved to

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
							an open site.
Jaipur (3) IMD	Banas	Jaipur	185	26°55´00"	75°50´00"	2/6/2011	Rain recorder positioned on a 2 story building, disturbed by high nearby high building.
Chomu Tehsil	Shekhawati	Jaipur	426	27°10´00"	75°40´00"	25/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.
Sikar WRD	Outside Basin	Sikar	534	27°37´00"	75°08´00"	25/8/2011	Daily rainfall station positioned on the ground, disturbed by vegetation to be cut.
Sikar Tehsil WRD	Outside Basin	Sikar	535	27°37´00"	75°08´00"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building disturbed by high nearby high building.
Udaipurwati Tehsil	Outside Basin	Jhunjhunu	422	27°43´00"	75°28´00"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building disturbed by trees to be cut...
Nawalgarh Tehsil	Outside Basin	Jhunjhunu	782	27°51´00"	75°16´12"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Jhunjhunu Tehsil	Outside Basin	Jhunjhunu	436	28°08´00"	75°23´00"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Fatehpur Tehsil	Outside Basin	Sikar	532	27°59´00"	74°58´00"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Laxmangarh Tehsil	Outside Basin	Sikar	533	27°50´00"	75°02´00"	25/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Bandra Sendri Police Station WRD	Banas	Ajmer	630	26°52´12"	74°56´03"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Kishangarh Tehsil	Banas	Ajmer	158	27°49´00"	76°36´00"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building, disturbed by a tree.
Ajmer (1) IMD	Banas	Ajmer	423	26°27´00"	74°37´00"	29/8/2011	Daily rainfall station positioned on the ground, disturbed by vegetation and fence. Station should be moved to an open area.
Mangaliawas Police Station	Banas	Ajmer	344	26°17´00"	74°30´00"	29/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.
Beawar WRD	Banas	Ajmer	343	26°06´00"	74°19´00"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Beawar Tehsil	Banas	Ajmer	-	26°06´00"	74°19´00"	29/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.
Bhim Tehsil	Banas	Rajsamand	152	25°45´00"	74°48´00"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Deogarh Tehsil	Banas	Rajsamand	153	25°34´00"	73°58´00"	29/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.

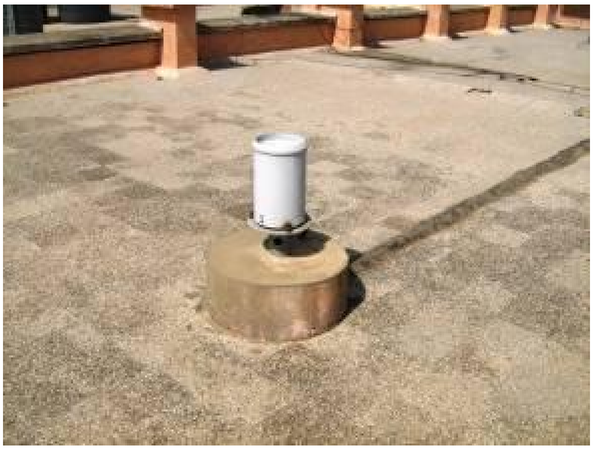
Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
Rajsamand Tehsil	Banas	Rajsamand	-	25°04´00"	73°53´00"	29/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.
Rajsamand Dam	Banas	Rajsamand	81	25°04´00"	73°53´00"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Nathdwara Tehsil	Banas	Rajsamand	78	24°55´00"	73°50´00"	29/8/2011	Daily rainfall station positioned on the ground, disturbed by vegetation.
Nandsamand Dam WRD	Banas	Rajsamand	779	25°51´00"	73°47´00"	29/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Daya Dam WRD	Mahi	Udaipur	670	24°15´10"	73°48´15"	30/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Jaisamand Dam (1) WRD	Mahi	Udaipur	299	24°14´00"	73°57´00"	30/8/2011	Daily rainfall station positioned on the ground.
Salumber WRD	Mahi	Udaipur	848	24°02´00"	74°12´00"	30/8/2011	Daily rainfall station positioned on the roof of a 2 stories building.
Banswara IMD	Mahi	Banswara	265	23°33´00"	74°27´00"	30/8/2011	Daily rainfall station positioned on the ground.
Mahi Dam WRD	Mahi	Banswara	274	23°38´00"	74°32´00"	30/8/2011	Daily rainfall station.
Mahi Dam IMD	Mahi	Banswara	274	23°38´00"	74°32´00"	30/8/2011	Automatic rain recorder satellite connected.
Dhariawad IMD	Mahi	Pratapgarh	580	24°06´00"	74°27´00"	30/8/2011	Rain recorder.
Udaipur WRD (1)	Banas	Udaipur	105	24°35´00"	73°42´00"	31/8/2011	Daily rainfall station positioned on the roof of a 3 stories building
Udaipur IMD (2)	Banas	Udaipur	104	24°35´00"	73°42´00"	31/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Gambhiri Dam WRD	Banas	Chittaurgarh	93	24°42´00"	74°43´00"	31/8/2011	Daily rainfall station positioned on the ground
Chittaurgarh	Banas	Chittaurgarh	89	24°53´00"	74°38´00"	31/8/2011	Daily rainfall station positioned on the roof of a 1 story building.
Chittaurgarh IMD	Banas	Chittaurgarh	88	24°53´00"	74°38´00"	31/8/2011	Rain recorder satellite connected.
Meja Dam WRD	Banas	Bhilwara	114	25°32´00"	74°33´00"	31/8/2011	Daily rainfall station positioned on the roof of a 1 story building.

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
Mahuwa WRD	Banganga	Dausa	228	27°03´00"	76°55´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1 story building. Trees too near
Bhusawar WRD	Banganga	Bharatpur	657	27°14´00"	77°30´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1 story building. Damage by monkeys
Weir Tehsil WRD	Gambhir	Bharatpur	219	27°01´00"	77°11´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1 story building. Trees too near. Damage by monkeys
Bayana Tehsil WRD	Gambhir	Bharatpur	73	26°54´00"	77°17´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1.5 story building. The rain gauge too low and test tube broken
Sewar WRD	Banganga	Bharatpur	88	27°15´00"	77°20´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1 story building. Trees too near
Ajan Dam WRD	Gambhir	Bharatpur	87	27°09´00"	77°32´00"	22/11/2011	Daily rainfall station positioned on the roof of a 1 story building.
Bilara Tehsil	Luni	Jodhpur	355	26°10'60"	73°42'00"	19/12/2011	Fixed on Roof top of Tehsil office Building. Instrument damaged needs to be replaced. Old instrument
Jaswant Sagar Dam	Luni	Jodhpur	353	26°13'00"	73°40'60"	19/12/2011	Fixed on J.S.Dam Rest Chowki. Old Instrument & Measuring JAR ok.
Jodhpur WRD	Luni	Jodhpur	520	26°18'00"	73°10'00"	20/12/2011	Fixed on Roof-top of A.C.E. office building. Instrument & JAR ok.
Surpura Dam	Luni	Jodhpur	526	27°34'48"	73°28'60"	20/12/2011	Fixed on Roof-top Chowkidar Hut at Surpura Dam site. Old instrument & JAR ok.
Jodhpur Tehsil	Luni	Jodhpur	518	26°18'00"	73°01'60"	20/12/2011	Fixed on Roof-top (2nd Floor) of Tehsil building. Instrument ok.
Pali WRD	Luni	Pali	372	25°46'48"	73°19'60"	20/12/2011	Fixed on Roof-top of XEN WRD office building. Instrument & JAR ok.
Hemawas Dam	Luni	Pali	371	25°46'00"	73°19'60"	20/12/2011	Fixed on Roof-top of Hemawas Dam Rest Chowki. Instrument & JAR ok.
Pali Tehsil	Luni	Pali	-	-	-	20/12/2011	Fixed on Roof-top of Tehsil Building. No obstruction, old instrument.
Pachpadra Tehsil	Luni	Barmer	350	25°55'60"	72°16'00"	21/12/2011	Fixed on Roof-top of Tehsil office building. No obstruction. Instrument & JAR damaged.
Balotra Tehsil	Luni	Barmer	354	25°49'60"	72°15'00"	21/12/2011	Need shifting: Fixed at Roof-top S.D.M. office building. Obstructed by building & trees.
Baitu Tehsil	Luni	Barmer	440	-	-	21/12/2011	Roof-top Tehsil office. No obstructions. Old instrument.

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
Barmer Tehsil	Luni	Barmer	438	25°45'00"	71°22'60"	21/12/2011	Roof-top Tehsil office. No obstructions. Instrument & JAR ok.
Shiv Tehsil	Luni	Barmer	443	26°10'60"	71°15'00"	21/12/2011	Roof-top Tehsil office new building. No obstruction. Instrument & JAR ok.
Jaisalmer Tehsil	Outside	Jaisalmer	511	26°53'60"	70°55'00"	21/12/2011	Fixed on Roof-top of Tehsil building. Obstructed by trees. Old instrument. New instrument & JAR available in Tehsil office. Fixing is to be done.
Pokran Tehsil	Outside	Jaisalmer	513	-	-	22/12/2011	Fixed on Roof-top of Tehsil building. No obstruction. Measuring glass damaged.
Phalodi Tehsil)	Outside	Jodhpur	524	27°07'60"	72°22'00"	22/12/2011	Fixed on Roof-top of Tehsil building. No obstruction. Old instrument. Measuring JAR is not correct. Instrument & JAR is to be changed.
Phalodi (A)	Outside	Jodhpur	523	27°08'01"	72°22'00"	22/12/2011	IMD station fixed at 2nd floor Roof-top of Local school teacher’s residence. No obstructions. Instrument & JAR ok
Kolayat Tehsil	Outside	Bikaner	447	27°34'60"	73°28'60"	22/12/2011	Fixed on Tehsil office building Roof-top. No obstructions. Instrument & JAR ok.
Bikaner Tehsil	Outside	Bikaner	445	28°01'00"	73°17'60"	22/12/2011	Fixed on Collectors office Roof-top (3rd floor). No obstructions. Instrument & JAR ok.
Lunkaransar Tehsil	Outside	Bikaner	446	28°30'00"	73°45'00"	23/12/2011	Fixed on Tehsil office building Roof-top. No proper measuring facilities. (No stairs/ladder). No obstructions. Instrument & JAR ok.
Suratgarh Tehsil	Outside	Ganganagar	502	29°19'00"	73°54'00"	23/12/2011	Fixed on Tehsil office building Roof-top. No stairs / Ladder facilities. Old instruments. Measuring JAR not correct. Instrument & Measuring JAR need replacement.
Pilibanga Tehsil	Outside	Hanumangarh	492	29°26'60"	74°04'00"	23/12/2011	Presently no instrument available for Tehsil Rainfall measurement. New instrument & measuring JAR available in tehsil office (Lying in store). Instrument needs proper fixing.
Hanumangarh Tehsil	Outside	Hanumangarh	475	29°34'60"	74°19'00"	23/12/2011	Fixed on Collector’s office Roof-top (2ed floor). Old instrument & JAR ok but damaged.
Rawatsar Tehsil	Outside	Hanumangarh	809	29°09'36"	74°13'48"	23/12/2011	Fixed on SDO office Roof-top. No obstructions. Instrument & JAR ok.
Sardar Shahar Tehsil	Outside	Churu	455	28°15'00"	74°19'12"	23/12/2011	Fixed on Tehsil office Roof-top (3rd floor). New instrument & JAR ok. No obstructions.

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date of visit	Findings
Jhalarapatan	Chambal	Jhalawar	37	24˚33 ´00"	76˚09 ´00"	19/1/2012	Fixed at Jhalarapatan Tehsil Roof top. Instrument measuring JAR ok.
Kalisindh Dam site	Chambal	Jhalawar	42	24˚36 ´00"	76˚10 ´00"	19/1/2012	Fixed at Kalisindh Dam site compound. Instrument measuring JAR ok.
Jhalawar SE office	Chambal	Jhalawar	36	24˚32 ´00"	76˚10 ´00"	19/1/2012	Fixed at S.E. Jhalawar office compound. Instrument measuring JAR ok.
Alnia Dam Rest House Compound	Chambal	Kota	22	24˚58 ´00"	75˚53 ´00"	20/1/2012	Fixed at Alnia Dam Rest House compound. Instrument and measuring JAR ok. Trees obstruction.
Kota Airport	Chambal	Kota	15	25˚11 ´00"	75˚50 ´00"	20/1/2012	IMD station – Kota Airport Temperature Recording point. IMD station Kota Airport manual operated Rainfall recorder. I.M.D. station Kota Airport Automatic Rainfall recorder.
Kota Barrage AEN Office	Chambal	Kota	17	25˚11 ´00"	75˚50 ´00"	20/1/2012	Fixed at AEN office compound at Kota Barrage manual Rainfall recorder old instrument.
Talera Tehsil	Chambal	Bundi	52	25˚20 ´00"	75˚43 ´00"	20/1/2012	Fixed at Talera sub Tehsil Roof top. Instrument & JAR ok.
Burdha Dam	Chambal	Bundi	36	25˚15 ´00"	75˚43 ´00"	20/1/2012	Fixed at Burdha Dam Rest chowki compound. Instrument JAR ok.
Bundi Tehsil	Chambal	Bundi	48	25˚27 ´00"	75˚38 ´00"	20/1/2012	Fixed at Bundi Tehsil office compound. Instrument & measuring JAR ok.
Bundi IMD	Chambal	Bundi		25˚27 ´00"	75˚38 ´00"	20/1/2012	I.M.D. station Bundi Tehsil temperature recorder. I.M.D. station Bundi Tehsil. I.M.D. Rainfall satellite operated station.
Hindoli Tehsil	Chambal	Bundi	50	25˚35 ´00"	75˚30 ´00"	20/1/2012	Fixed at Hindoli Tehsil Roof top. Instrument & measuring JAR ok.

Shapura Tehsil Daily Rainfall Station (Instrument on the Roof)



Rain Recorder on the Roof of the Water Resources Department Main Office Building, Jaipur

Irrigation Colony Rainfall Station Lalsot (Instruments on the Roof)

Irrigation Colony Weather Station Mahaveerji – Automatic Rain Recorder, its Data Logger Housing and Daily Rainfall Measurement Facility

Chhaparwara Dam Daily Rainfall Station Measurement Facility

Ramgarh Dam Daily Rainfall Stations

Morel Dam Daily
Rainfall Station

Malakhera Tehsil -
Non Functioning
Rain Recorder

Chomu Tehsil Rainfall Station
Chomu – Daily Rainfall
Measurement Facility

Sikar WRD Rainfall Station
Chomu – Daily Rainfall
Measurement Facility

Sikar Tehsil Rainfall Station
Sikar – Daily Rainfall
Measurement Facility

Udaipurwati Tehsil Rainfall Station
Udaipurwati – Daily Rainfall
Measurement Facility

Nawalgarh Tehsil Rainfall Station Nawalgarh – Daily Rainfall Measurement Facility

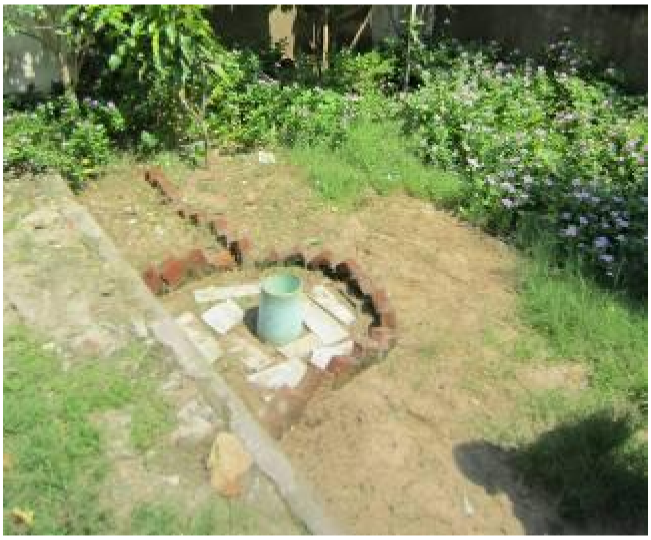
Jhunjhunu Tehsil Rainfall Station Jhunjhunu – Daily Rainfall Measurement Facility

Fatehpur Tehsil Rainfall Station Fatehpur – Daily Rainfall Measurement Facility

Lachhmangarh Tehsil Rainfall Station Lachhmangarh – Daily Rainfall Measurement Facility

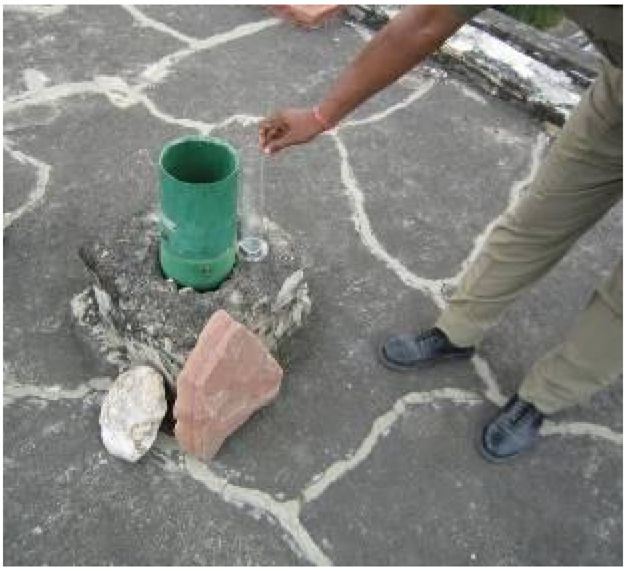
Bandra Sendri Rainfall– Daily Rainfall Measurement Facility

Kishangarh Tehsil Rainfall Station Kishangarh – Daily Rainfall Measurement Facility



Ajmer WRD Rainfall Station – Daily Rainfall Measurement Facility

Mangaliawas Rainfall Station – Daily Rainfall Measurement Facility



Beawar WRD Rainfall Station (Instrument on the Roof)

Beawar Tehsil Rainfall Station – Daily Rainfall Measurement Facility

Bhim Tehsil Rainfall Station – Daily Rainfall Measurement Facility

Deogarh Tehsil Rainfall Station – Daily Rainfall Measurement Facility

Rajsamand Tehsil Rainfall Station – Daily Rainfall Measurement Facility

Rajsamand Dam Rainfall Station – Daily Rainfall Measurement Facility

Nathdwara Tehsil Rainfall Station – Daily Rainfall Measurement Facility (2)

Nandsamand Dam Rainfall Station – Daily Rainfall Measurement Facility

Daya Dam Daily Rainfall Station (Instrument on the Roof)

Jaisamand Dam Rainfall Station – Daily Rainfall Measurement Facility

Salumber WRD Rainfall Station – Daily Rainfall Measurement Facility

Banswara WRD Rainfall Station – Daily Rainfall Measurement Facility

MAHI Dam Rainfall Station – Daily Rainfall Measurement Facility (Manual)

MAHI Dam Rainfall Station – Rain Recorder with Satellite Connections

Dhariawad WRD Weather Station – Daily Rainfall Measurement Facility (Manual)

Dhariawad WRD Weather Station – Rain Recorder

MAHI Dam Rainfall Station – Rain Recorder with Satellite Connections

Udaipur WRD Headquarters Rainfall Station – Daily Rainfall Measurement Facility (Manual)

Udaipur WRD Lake Fatehsagar Rainfall Station – Daily Rainfall Measurement Facility (Manual)

Gambhiri Dam Rainfall Station – Daily Rainfall Measurement Facility (Manual)

Chittorgarh WRD Weather Station – Daily Rainfall Measurement Facility (Manual)

Chittorgarh WRD Weather Station – Rainfall Recorder

Meja Dam WRD Rainfall Station – Daily Rainfall Measurement Facility (Manual)

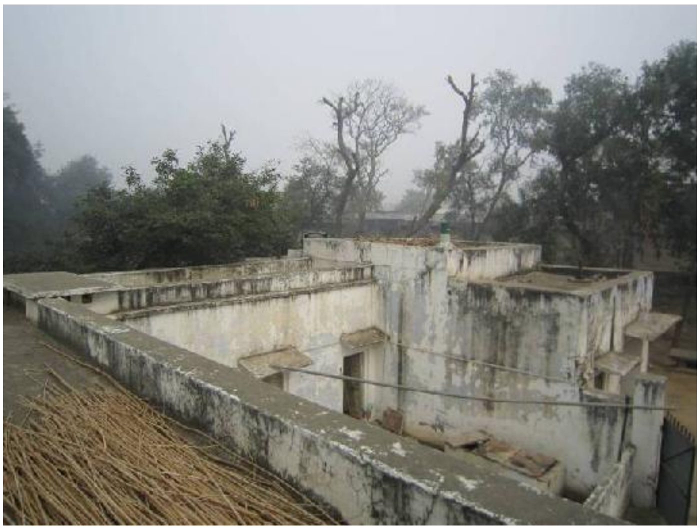
Shahpura Tehsil Daily Rainfall Measurement Facility

Rainfall Measurement near the Banas River Hydrometric Station on NH12 near Tonk

Rainfall and Temperatures Measurement at the Kanota Bund, Jaipur

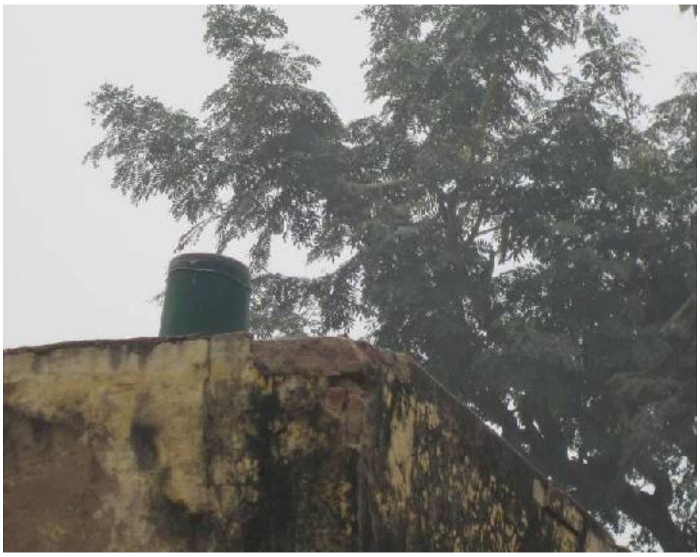
Mahuwa WRD Rainfall Station Site

Mahuwa WRD Rainfall Station – the Rain Measurement Facility



Mahuwa WRD Rainfall Station – Trees that Disturb Proper Observations

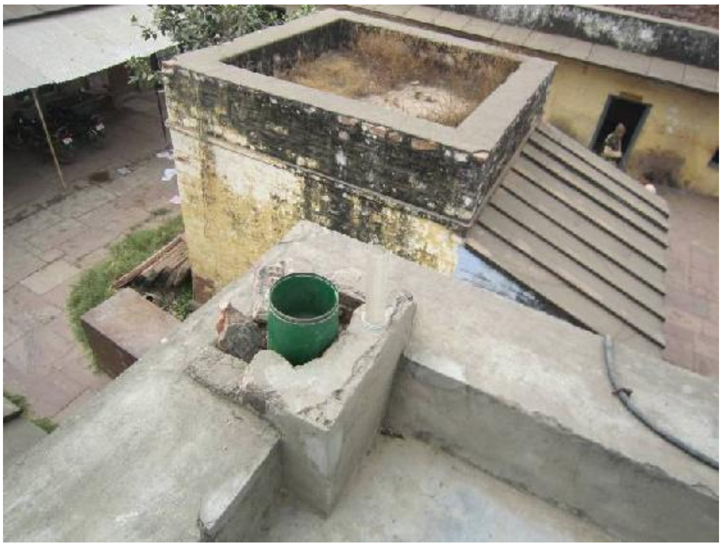
Bhusawar WRD Rainfall Station Site



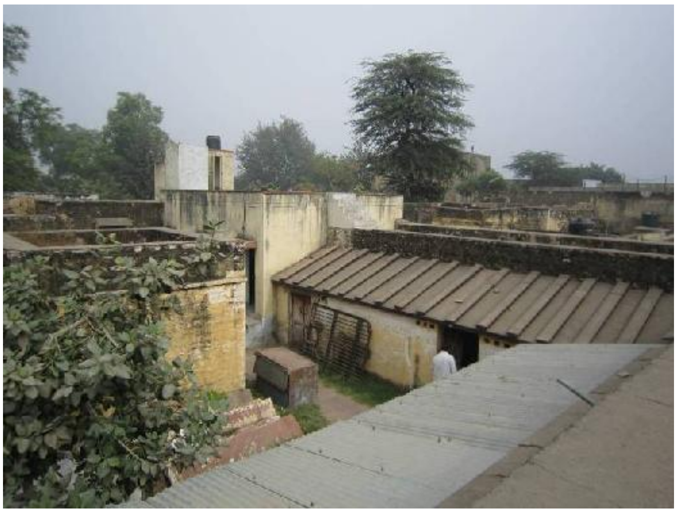
Bhusawar WRD Rainfall Station – a Closer Look

Weir Tehsil WRD Rainfall Station - the Rain Measurement Facility

Weir Tehsil WRD Rainfall Station Site



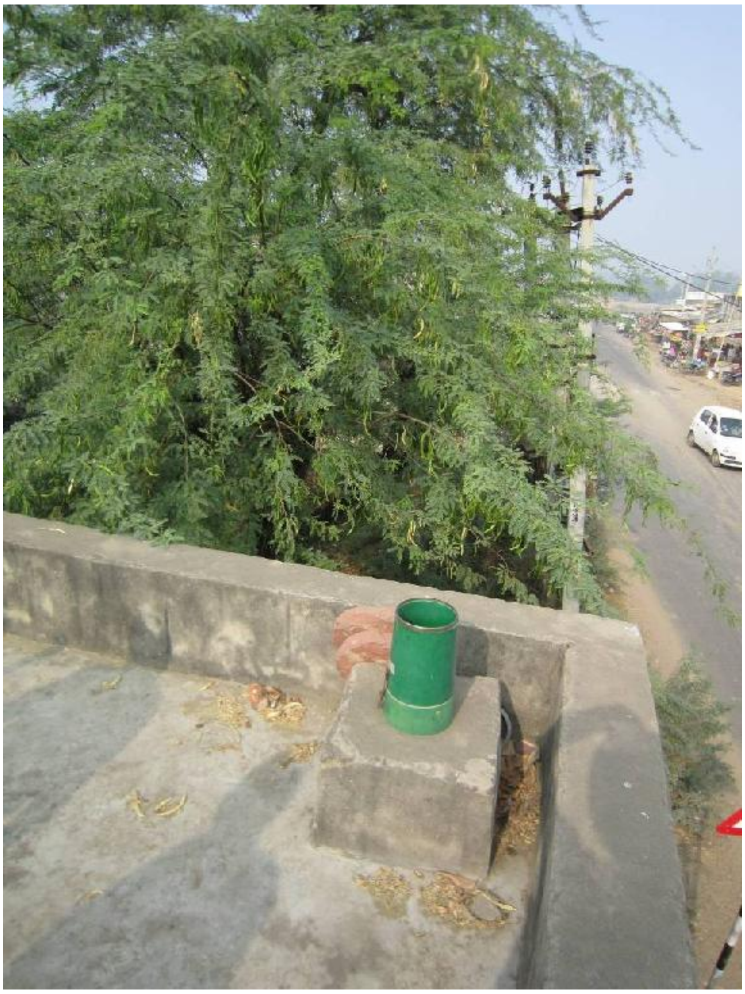
Bayana Tehsil WRD Rainfall Station - the Rain Measurement Facility (installed too low)



Bayana Tehsil WRD Rainfall Station – General View

Bayana Tehsil WRD Rainfall Station Site

Sewar WRD Rainfall Station Site



Sewar WRD Rainfall Measurement Facility - A tree that Disturbs Proper Observations

Ajan Dam WRD Rainfall Station Site

Rainfall Recorder Jaswant Sagar Dam – Rest Chowki Luni River Basin. Old instrument and Measuring Jar ok

Rainfall Recorder Jaswant Sagar Dam – Rest Chowki Luni River Basin. Old instrument and Measuring Jar ok

Rainfall Recorder Jodhpur – ACE Office. 1st Floor Roof top. Old instrument and Measuring Jar ok

Rainfall Recorder Jodhpur – Surpura Dam. Chowkidar Hut Roof top. Old instrument and Measuring Jar ok

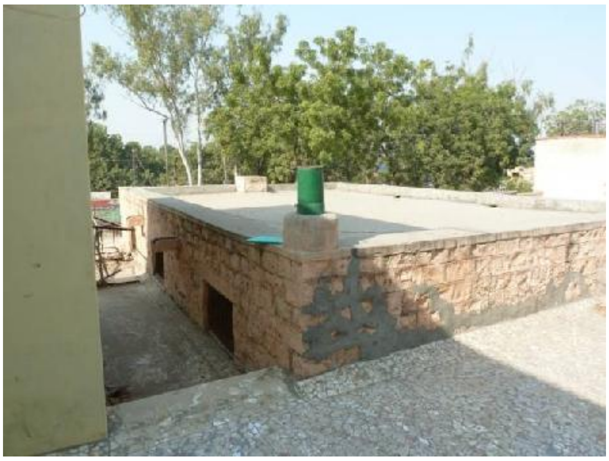
Rainfall Recorder Jodhpur Tehsil Office 2nd Floor, Roof top. Instrument and Measuring Jar ok

Rainfall Recorder Pali – W.R. Dn. Office, 1st Floor Roof Top. Instrument and Measuring Jar ok

Rainfall Recorder Pali – Hemawas Dam Rest Chowki – Roof top. Instrument and Measuring Jar ok

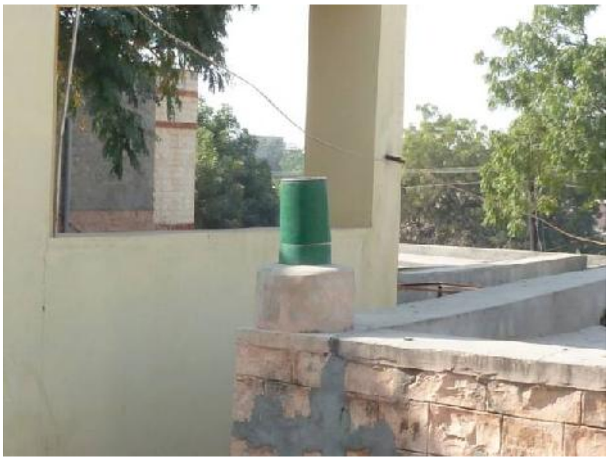
Rainfall Recorder Pali Tehsil Office, Roof top. Old instrument

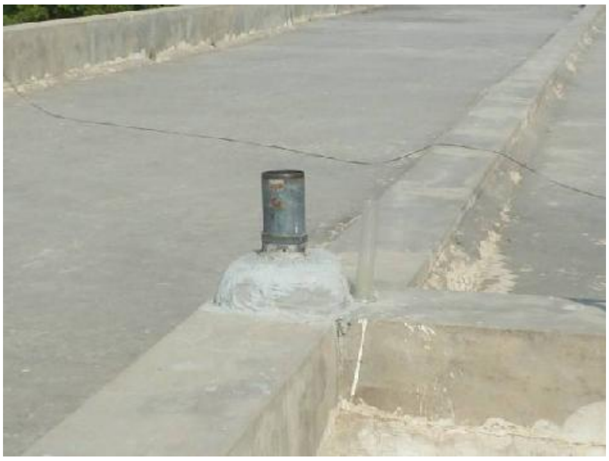
Rainfall Recorder Pachpadra – Barmer district Tehsil office – Roof Top. Instrument and Measuring Jar damaged.



Rainfall Recorder Balotra SDM
Office Roof Top – Barmer
Obstructed by building and Trees
Need Shifting

Rainfall Recorder Balotra SDM
Office Roof Top – Barmer
Obstructed by building and Trees
Need Shifting





Rainfall Recorder Baitu – Barmer
Tehsil office Roof top. Old
Instrument

Rainfall Recorder Barmer Tehsil office , Roof top. Instrument and Jar ok.

Rainfall Recorder Shiv Tehsil office New Building. Instrument and Jar ok.

Rainfall Recorder Shiv Tehsil office New Building. Instrument and Jar ok.

Rainfall Recorder Jaisalmer Tehsil Office, Roof top. Obstructed by Trees. Old instrument need shifting, new jar and instrument available in tehsil office.

Rainfall Recorder Jaisalmer Tehsil Office, Roof top. Obstructed by Trees. Old instrument need shifting, new jar and instrument available in Tehsil office.

Rainfall Recorder Pokhran Tehsil office. Measuring glass damaged.

Rainfall recorder Phalodi – Tehsil office, old instrument. Measuring Jar not correct instrument and jar is to be changed.

Rainfall recorder Phalodi – Tehsil office, old instrument. Measuring Jar not correct instrument and jar is to be changed.

Phalodi – IMD Rainfall Recorder at Sr. Teacher's residence, 2nd floor roof top. Instrument and measuring glass is ok.

Phalodi – IMD Rainfall Recorder at Sr. Teacher’s residence, 2nd floor roof top. Instrument and measuring glass is ok.

Rainfall recorder Kolayat Tehsil office roof top. Instrument and jar is ok.

Rainfall recorder Bikaner – Collector’s office 3rd floor roof top. Instrument and jar is ok.

Rainfall recorder Bikaner – Collector's office 3rd floor roof top. Instrument and jar is ok.

Rainfall recorder Lunkaransar – Tehsil office Roof top. No proper measuring facilities (No stairs /wooden ladder) instrument and jar ok.

Rainfall recorder Suratgarh – Tehsil office roof top No stairs / ladder facilities instrument and measuring jar not correct. Need replacement.

Rainfall recorder Pilibanga No instrument fixed in Tehsil office. New instrument and measuring jar available in Tehsil office store, need proper fixing.

Rainfall recorder Hanumangarh – collector’s office roof top, 2nd floor. Old instrument, Jar ok but damaged.

Rainfall recorder Hanumangarh – collector’s office roof top, 2nd floor. Old instrument, Jar ok but damaged.

Rainfall recorder Rawatsar, SDO office roof top, 2nd floor, old instrument and jar ok but damaged.

Rainfall recorder Churu Sardarshahar – Tehsil office roof top, 3rd floor, new instrument and jar ok.

b. Meteorological Stations

Station Name	Basin	District	WRIS Code	Latitude	Longitude	Date Visited	Findings
Bandikui WRD	Banganga	Dausa	645	27°02´59"	76°34´23"	25/5/2011	Automatic weather station that stopped to function due to sabotage.
Kanota WRD	Banas	Jaipur	186	26°53´00"	75°56´00"	1/3/2011	The meteorological station has wind speed and direction facilities, temperatures hut to measure maximum and dew point temperatures and solar radiation measurement instrument. Trees near the station should be cut.
Lalsot (Irrigation Colony)	Banas	Dausa	187	26°33´00"	76°20´00"	25/5/2011	The meteorological station has wind speed and direction facilities, temperatures hut to measure maximum and dew point temperatures and solar radiation measurement instrument.
Sodawas WRD	Sabi	Alwar	258	27°54´00"	76°11´00"	31/5/2011	Meteorological station partially abandoned. Rainfall facility measurements might function. Trees near the station should be cut.
Jaipur (1)	Banas	Jaipur	183	26°55´00"	75°50´00"	2/6/2011	Automatic meteorological station with no processing
Ajmer (2)	Banas	Ajmer	424	26°72´00"	74°37´00"	29/8/2011	Non-functioning weather station on the roof of 3 stories building.
Beawar Tehsil WRD	Banas	Ajmer	343	26°06´00"	74°19´00"	29/8/2011	Wind speed and direction on the roof of a 1 story building.
Jaisamand dam (2)	Mahi	Udaipur	299	24°14´00"	73°57´00"	30/8/2011	Non-functioning weather station on the ground
Dhariawad	Mahi	Pratapgarh	288	24°06´00"	74°27´00"	30/8/2011	Weather station
Udaipur (3)	Banas	Udaipur	105	24°35´00"	73°42´00"	30/8/2011	Non-functioning weather station on the roof of 3 stories building.
Bharatpur WRD	Banganga	Bharatpur	70	27°13´00"	77°30´00"	22/11/2011	Daily rainfall and rain recorder measurement facilities installed n the ground. The rain recorder is not functioning due to maintenance problems. There is a temperatures hut. The fence is destroyed. Vegetation near the station should be cut
Bharatpur IMD	Banganga	Bharatpur	207	27°13´00"	77°30´00"	22/11/2011	Automatic rain recorder and temperatures hut satellite connected. Trees too near.

Sodawas Meteorological Station
(partially abandoned)

Malakhera Tehsil Non
Functioning Rain Recorder

Irrigation Colony Weather Station Mahaveerji – Wind Speed and Wind Direction Measurement Instruments

Automatic Meteorological Station on the Roof of the Water Resources Department Major Office Building, Jaipur

Daily Rainfall and Temperatures Measurement Facilities located at the Water Resources Department Head Office Yard, Jaipur

Ajmer WRD Non - Functioning Weather Station – the Wind Direction and Solar Radiation Facilities

Beawar Tehsil Wind Speed and Direction Station on the Roof

Jaisamand Dam Non – Functioning Weather Station

Banswara WRD Non – Functioning Weather Station

Dhariawad WRD Weather Station – Temperatures Hut

Dhariawad WRD Weather Station – Class 'A' Pan

Dhariawad WRD Weather Station – Wind Direction and Speed Measurements Facilities

Dhariawad WMD Weather Station (Wind Direction and Wind Speed Facilities) and IMD Rainfall Station on the Roof

Udaipur WRD Headquarters Non- Function Weather Station

Chittorgarh WRD Weather Station – Temperatures Hut

Chittorgarh WRD and IMD Meteorological Stations – a General View

Chittorgarh WRD Weather Station – Wind Direction and Wind Speed Measurement Facilities

Solar Radiation Measurement at the Kanota Climatological Station

Wind Direction Measurement at the Kanota Climatological Station

Wind Speed Measurement at the Kanota Climatological Station

Bharatpur WRD Weather Station – the Rainfall Measurement Facilities

Bharatpur WRD Weather Station – the Thermometers Hut

Bharatpur IMD Weather Station

Bharatpur IMD Weather Station - Trees that Disturb Proper Observations

Sodawas Meteorological Station – the Damaged Wind Vane

Irrigation Colony Weather Station Mahaveerji – Temperatures Measurements

Hydrometric Stations

Station Name	Basin	District	Latitude	Longitude	Date visited	Findings
Gambhiri	Gambhiri	Karauli	26°40´12"	76°57´08"	25/5/2011	Water level recorder
Kanota	Dun (Banas)	Jaipur	26°54´00"	75°56´00"	1/3/2011	Water level recorder not operating
Tonk	Banas	Tonk	26°12´00"	75°47´00"	3/3/2011	Staff gages
Sawa	Sawa (Banganga)	Dausa	27°02´59"	76°34´23"	25/5/2011	Water level recorder Cable way damaged
Meja Dam	Meja (Chambal)	Bhilwara	25°03´00"	74°33´00"	27/2/2011	Water level recorder
Kanota Dam	DHUNDH (Banas)	Jaipur	26°53´00"	75°57´00"	1/3/2011	Water level recorder
Kota Barrage	Chambal	Chittorgarh	25°10´34"	75°50´00"	3/3/2011	Water level recorder
Jawahar Sagar	Chambal	Chittorgarh	25°02´14"	75°40´40"	4/3/2011	Water level recorder
Rana Pratap Sagar	Chambal	Chittorgarh	24°55´04"	75°34´50"	4/3/2011	Water level recorder
Morel dam	Morel (Banas)	Dausa	26°26´36"	76°20´15"	25/5/2011	Water level recorder
Chhaparwara Dam	Meshi (Banas)	Jaipur	26°37´00"	75°14´45"	26/5/2011	Water level recorder
Ramgarh Dam	Banganga	Jaipur	27°03´30"	76°03´45"	31/5/2011	Water level recorder
Jaisamand Dam	Ruparail	Alwar	27°29´00"	76°35´45"	31/5/2011	Water level recorder
Sodawas	Sabi	Alwar	27°54´00"	76°24´00"	31/5/2011	Water level recorder(not functioning)
Rajsamand dam	Banas	Rajsamand	25°04´00"	73°53´00"	29/8/2011	Staff gage
Nandsamand dam	Banas	Rajsamand	25°51´00"	73°47´00"	29/8/2011	Staff gage
Jaisamand dam	Mahi	Udaipur	24°14´00"	73°57´00"	30/8/2011	Staff gage
Mahi dam	Mahi	Banswara	23°38´00"	74°32´00"	30/8/2011	Staff gage
Gambhiri dam	Banas	Chittaurgarh	24°42´00"	74°43´00"	31/8/2011	Staff gage
Meja dam	Banas	Bhilwara	25°32´00"	74°33´00"	31/8/2011	Staff gage

Morel Dam Water
Level Recorder

Gambhir River
Mahaveerji
Hydrometric Station

The Hydrometric Station of Dun
River near Kanota

Sawa River Bandikui Hydrometric Station (1)

Sawa River Downstream of Bandikui Hydrometric Station

Sabi River on Alwar Road (near Sodawas) Water Level Recorder

Sawa River Bandikui Hydrometric Station – Cable Way House (destroyed)

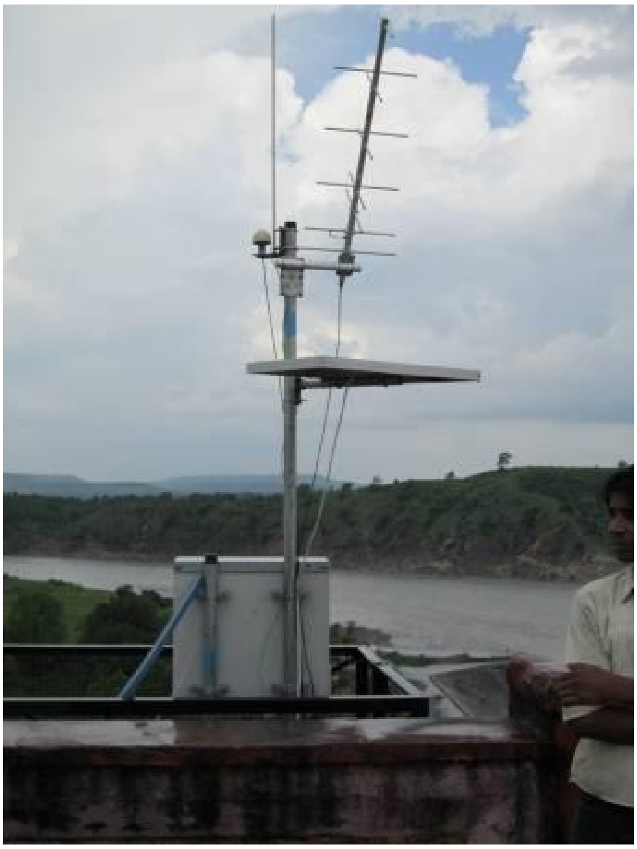
Sawa River Bandikui Hydrometric Station (2)

Ramgarh Dam Emergency Water Level recorder

Chhaparwara Dam
Water Level Recorder

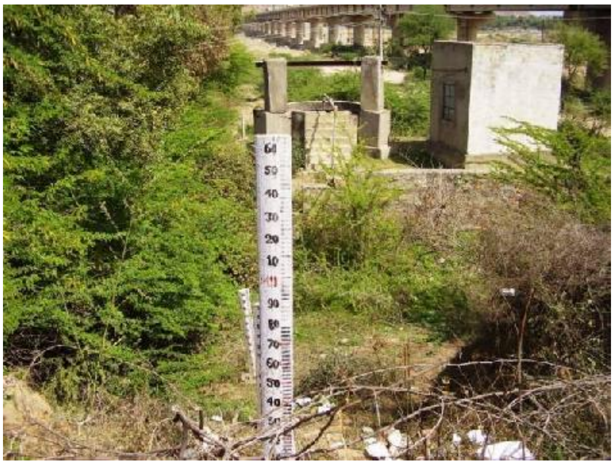
The Sabi River on Alwar Road (near Sodawas) Water Level Recorder

Gambhiri Dam and the Manual Water Level Measurement Facility



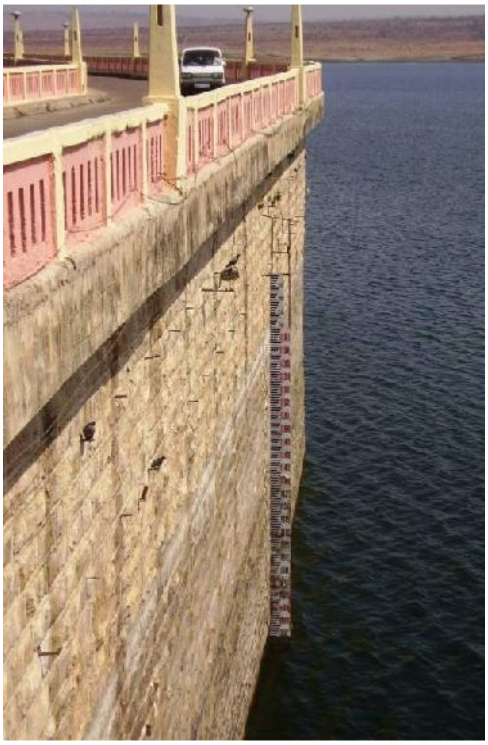
Mahi Dam Satellite Connections of the Rain Recorder and the Reservoir Water Level Recorder

Stuff Gages of The Banas River Hydrometric Station on NH12 near Tonk



Water Level Measurement Down Stream of The Banas River Hydrometric Station on NH12 near Tonk

Banas River Downstream of the Banas River Hydrometric Station on NH12 near Tonk



Water Level Measurements of the Rana Pratap Sagar Reservoir (Outdoors Measurements)

Water Level Measurements of the Rana Pratap Sagar Reservoir (Indoors Measurement)

Jaisamand Dam and the Manual Water Level Measurement Facility

Rajsamand Dam and the Manual Water Level Measurement Facility

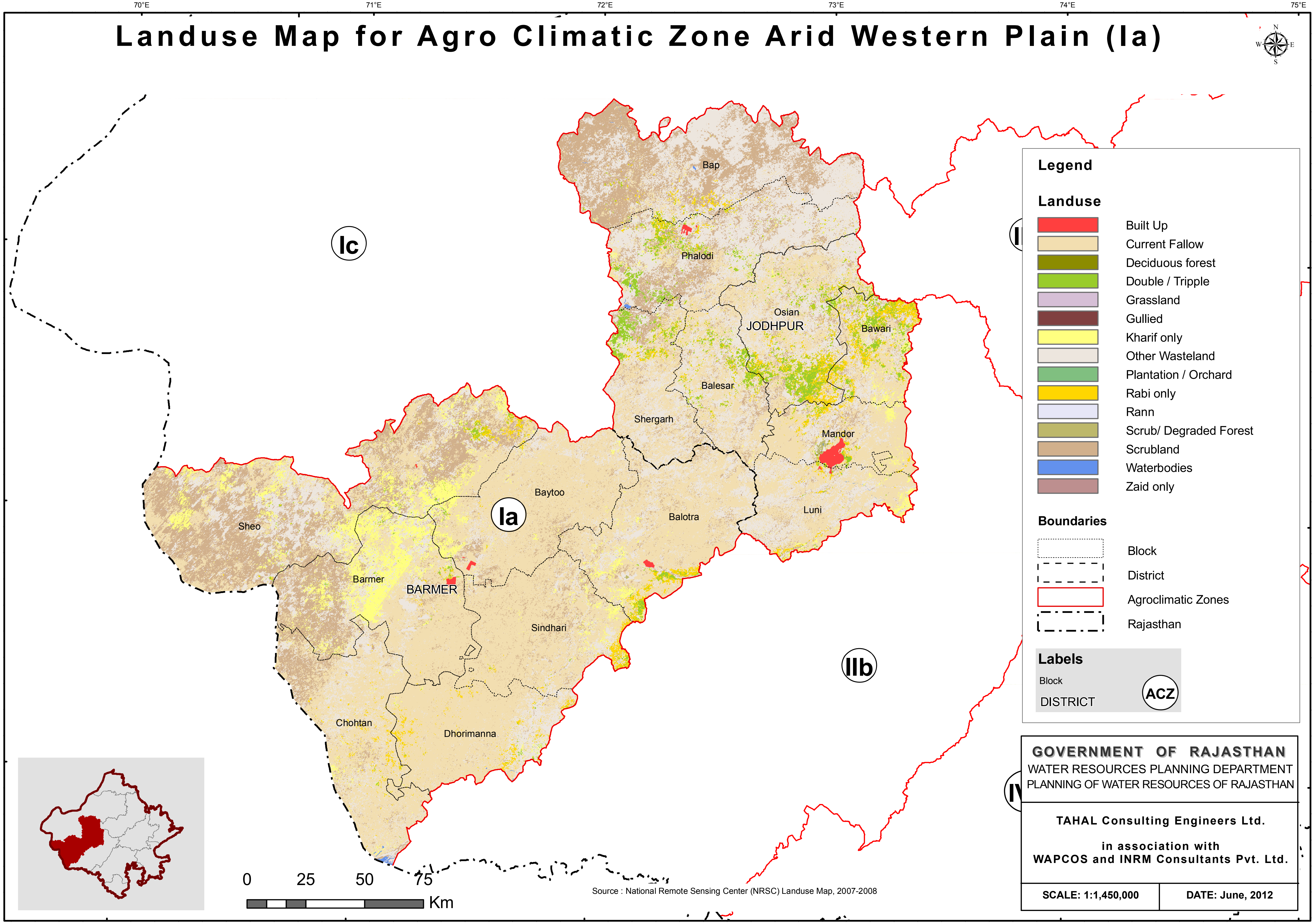
Mahi Dam and the Manual Water Level Measurement Facility

Final Report No. 4.1

Volume 3 of 3

Maps

Landuse Map for Agro Climatic Zone Arid Western Plain (Ia)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

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WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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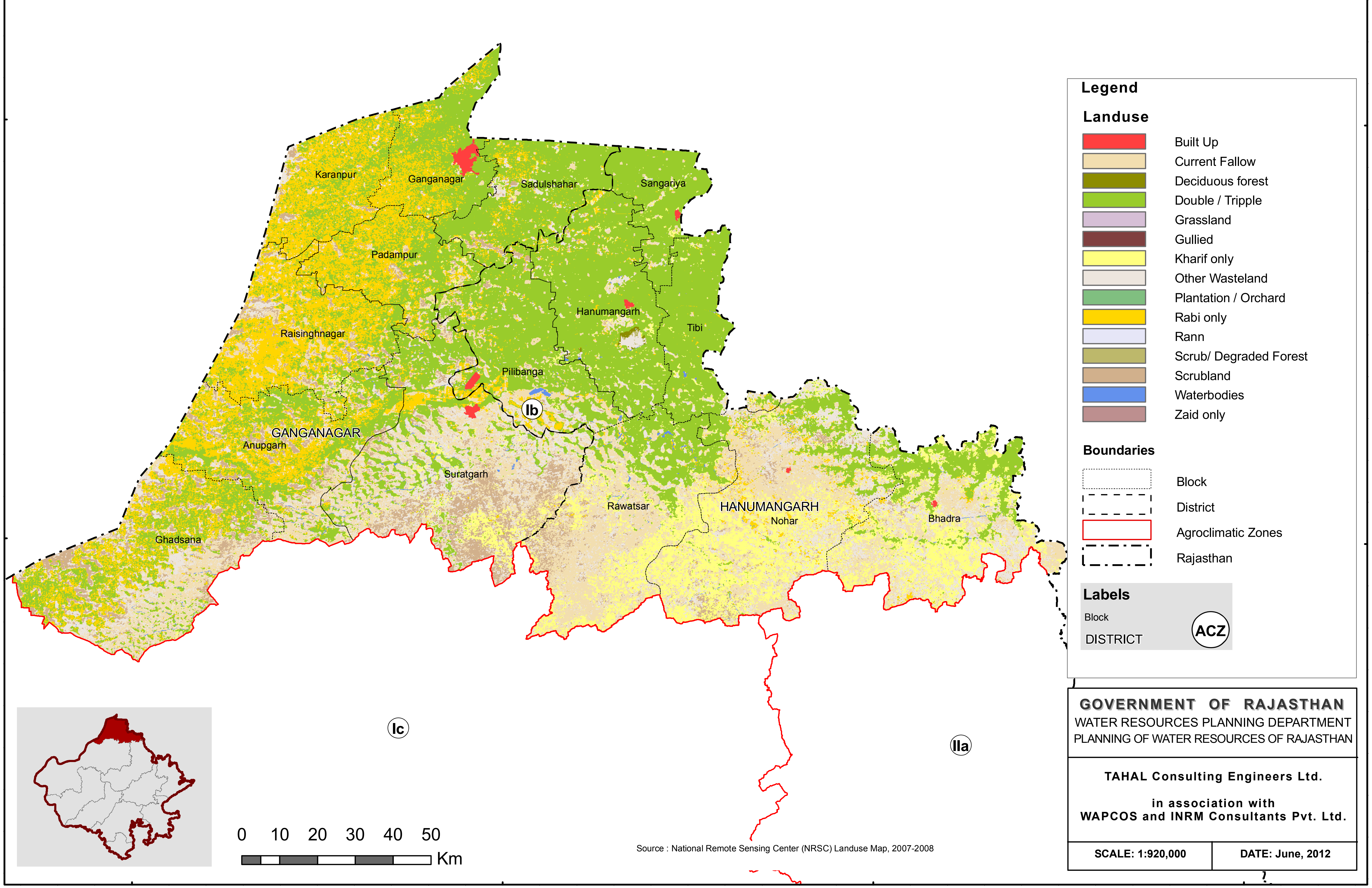
SCALE: 1:1,450,000
DATE: June, 2012

Landuse Map for Agro Climatic Zone Irrigated North Western Plain (Ib)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

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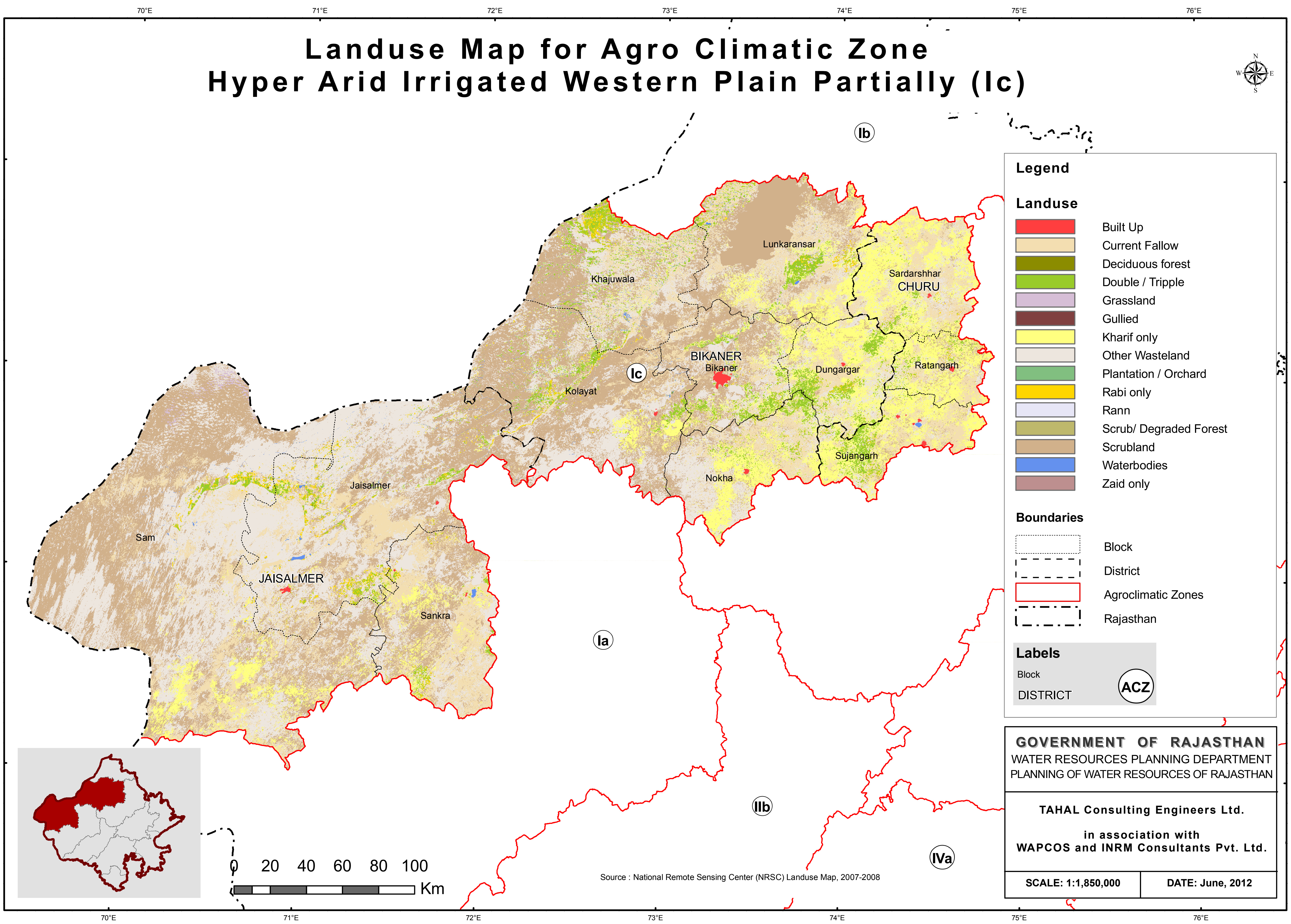
SCALE: 1:920,000	**DATE: June, 2012**

Landuse Map for Agro Climatic Zone Hyper Arid Irrigated Western Plain Partially (Ic)



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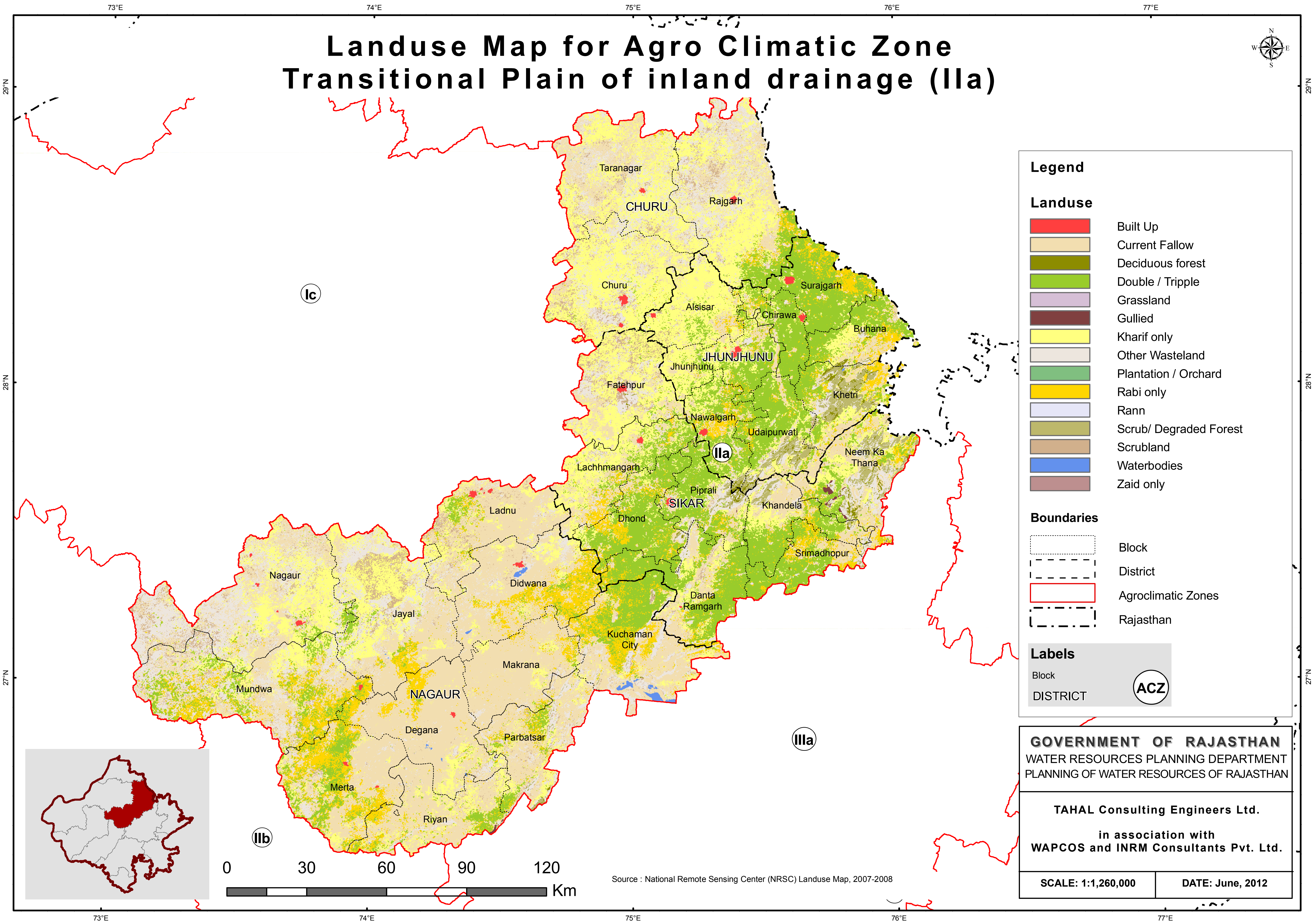
SCALE: 1:1,850,000 | **DATE: June, 2012**

Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

Landuse Map for Agro Climatic Zone Transitional Plain of inland drainage (IIa)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

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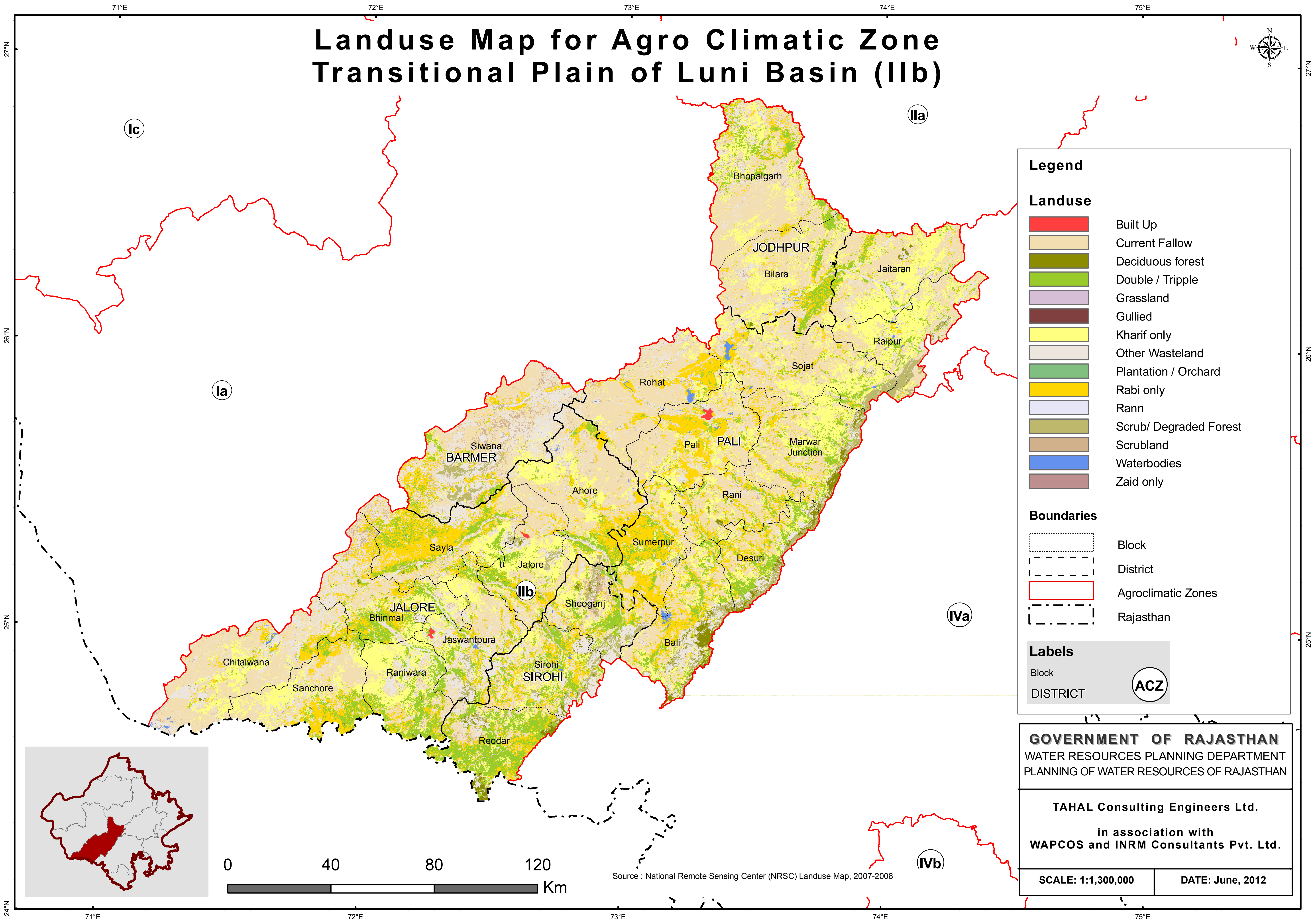
SCALE: 1:1,260,000 | **DATE: June, 2012**

Landuse Map for Agro Climatic Zone Transitional Plain of Luni Basin (IIb)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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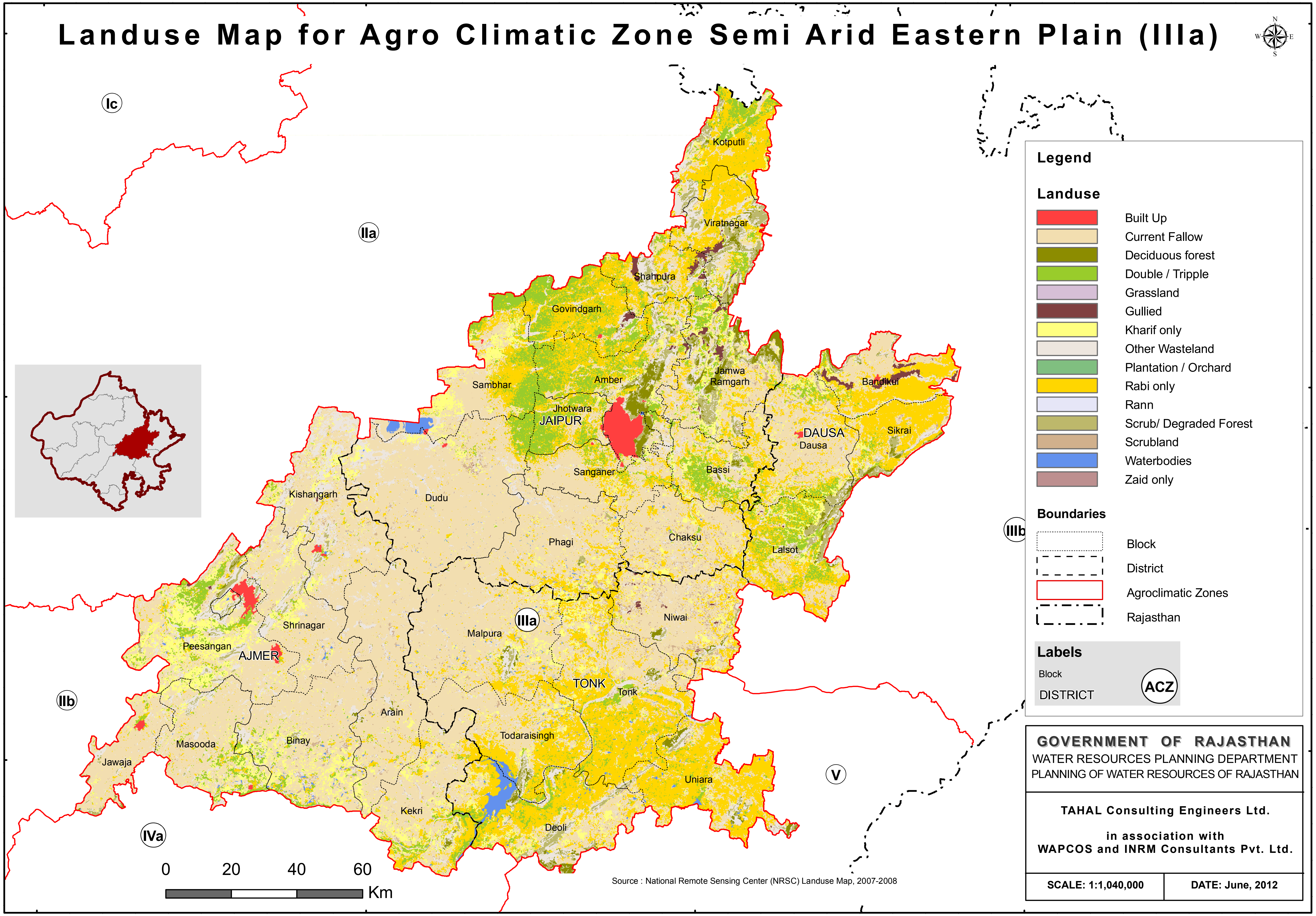
SCALE: 1:1,300,000	**DATE: June, 2012**

Landuse Map for Agro Climatic Zone Semi Arid Eastern Plain (IIIa)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

GOVERNMENT OF RAJASTHAN
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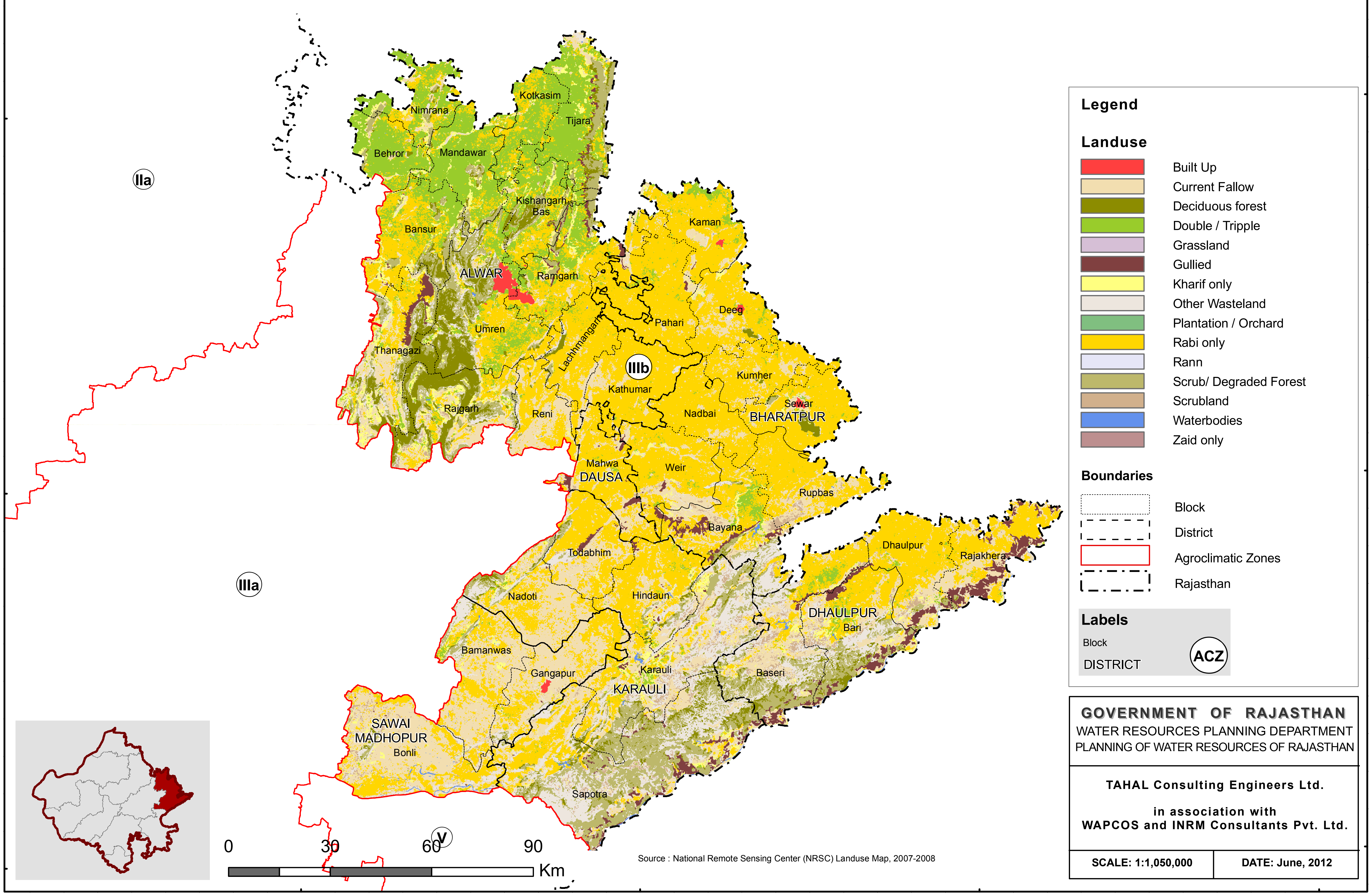
SCALE: 1:1,040,000

DATE: June, 2012

Landuse Map for Agro Climatic Zone Flood Prone Eastern Plain (IIIb)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

GOVERNMENT OF RAJASTHAN
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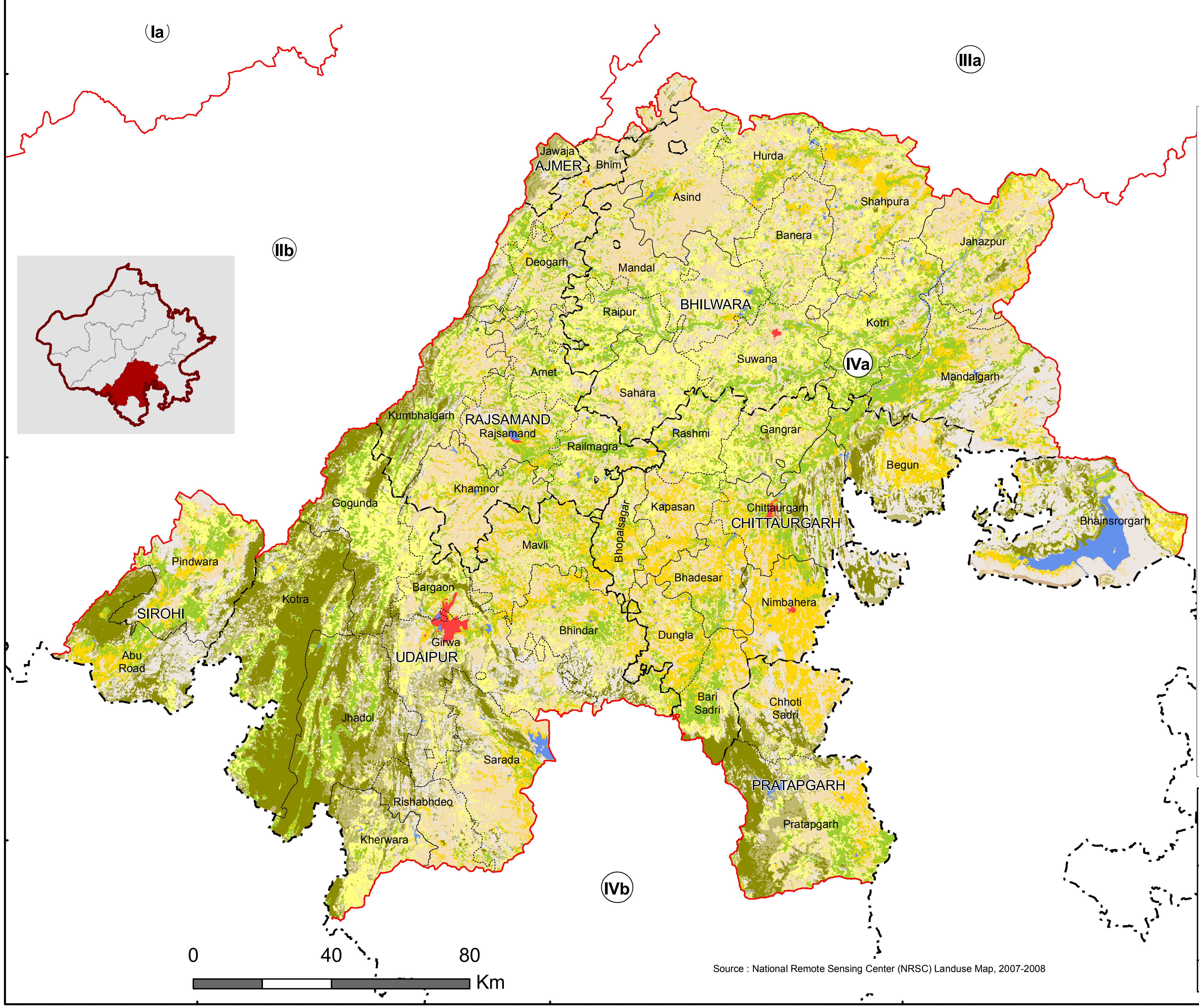
SCALE: 1:1,050,000 | **DATE: June, 2012**

Landuse Map for Agro Climatic Zone Sub humid Southern Plain (IVa)



Legend

Landuse

- 🟥 Built Up
- 🟫 Current Fallow
- 🟫 Deciduous forest
- 🟩 Double / Tripple
- 🟪 Grassland
- 🟫 Gullied
- 🟨 Kharif only
- ⬜ Other Wasteland
- 🟩 Plantation / Orchard
- 🟧 Rabi only
- ⬜ Rann
- 🟫 Scrub/ Degraded Forest
- 🟫 Scrubland
- 🟦 Waterbodies
- 🟫 Zaid only

Boundaries

- Block
- District
- Agroclimatic Zones
- Rajasthan

Labels

Block

DISTRICT

ACZ

Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

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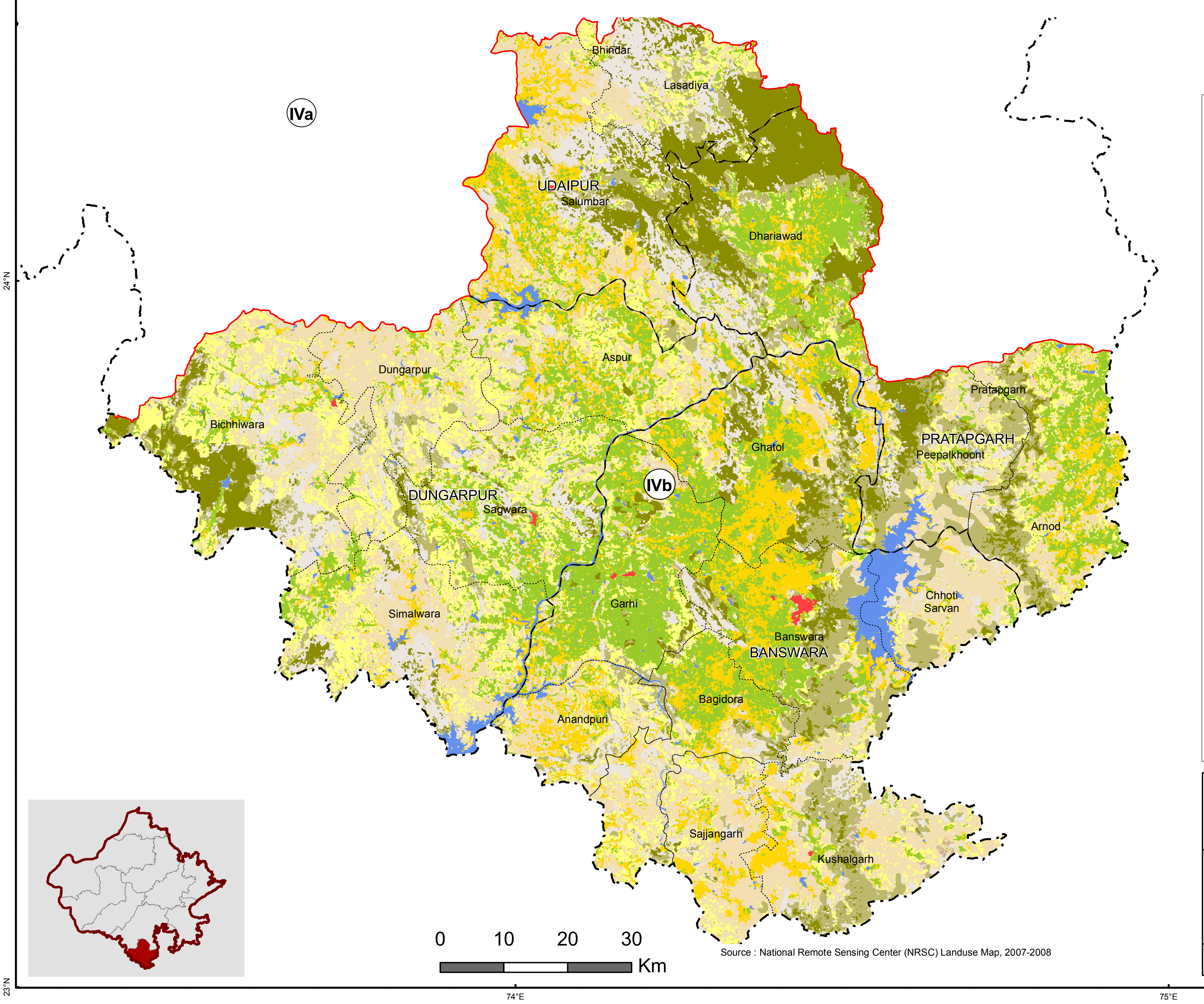
SCALE: 1:1,150,000	**DATE: June, 2012**

Landuse Map for Agro Climatic Zone Humid Southern Plain (IVb)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

Legend

Landuse

🟥	Built Up
▨	Current Fallow
▨	Deciduous forest
🟩	Double / Tripple
▨	Grassland
▨	Gullied
🟨	Kharif only
▨	Other Wasteland
🟩	Plantation / Orchard
🟨	Rabi only
▨	Rann
▨	Scrub/ Degraded Forest
▨	Scrubland
🟦	Waterbodies
▨	Zaid only

Boundaries

┈	Block
╌	District
☐	Agroclimatic Zones
─·─	Rajasthan

Labels

Block

DISTRICT

ACZ

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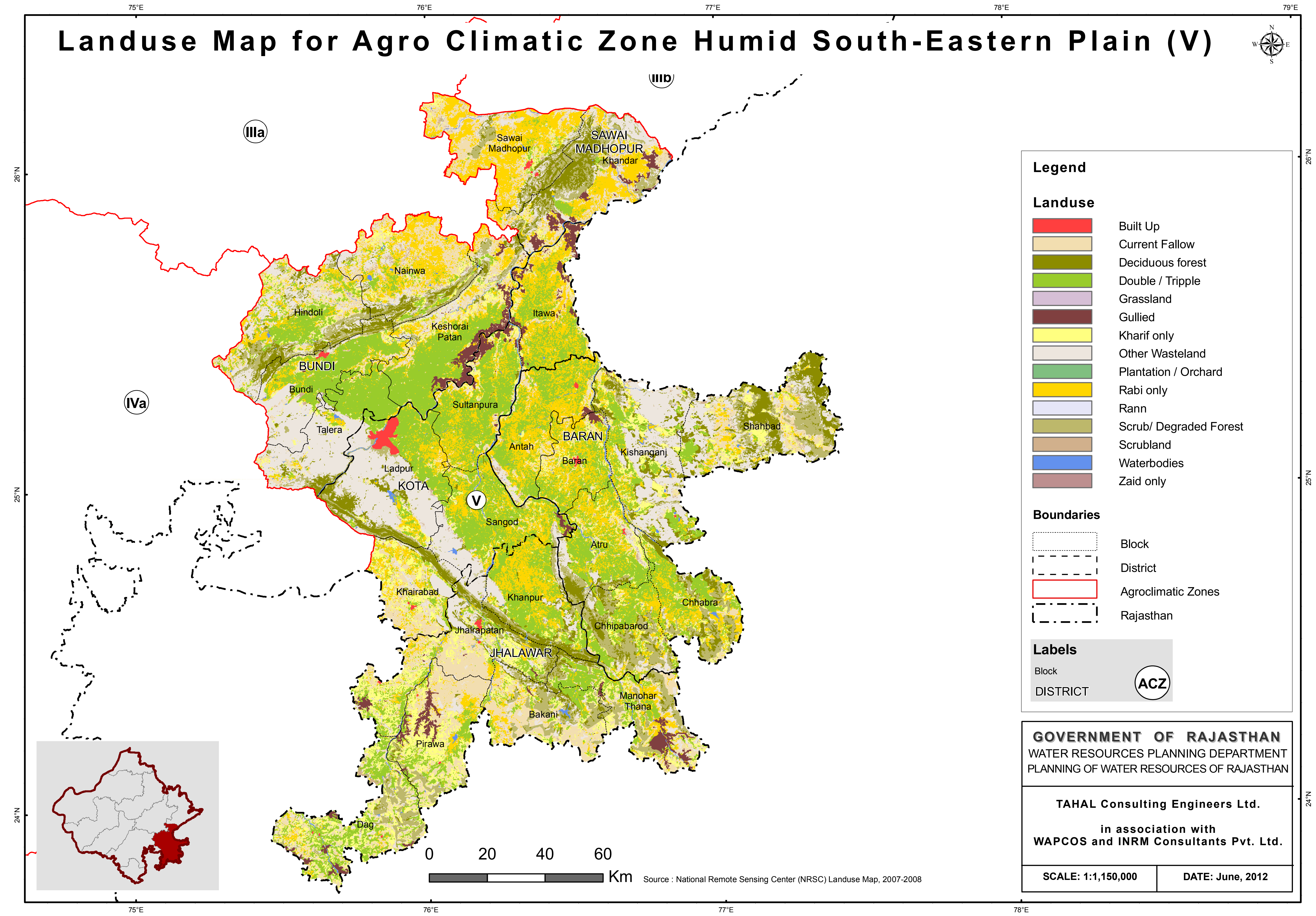
SCALE: 1:620,000	**DATE: June, 2012**

Landuse Map for Agro Climatic Zone Humid South-Eastern Plain (V)



Source : National Remote Sensing Center (NRSC) Landuse Map, 2007-2008

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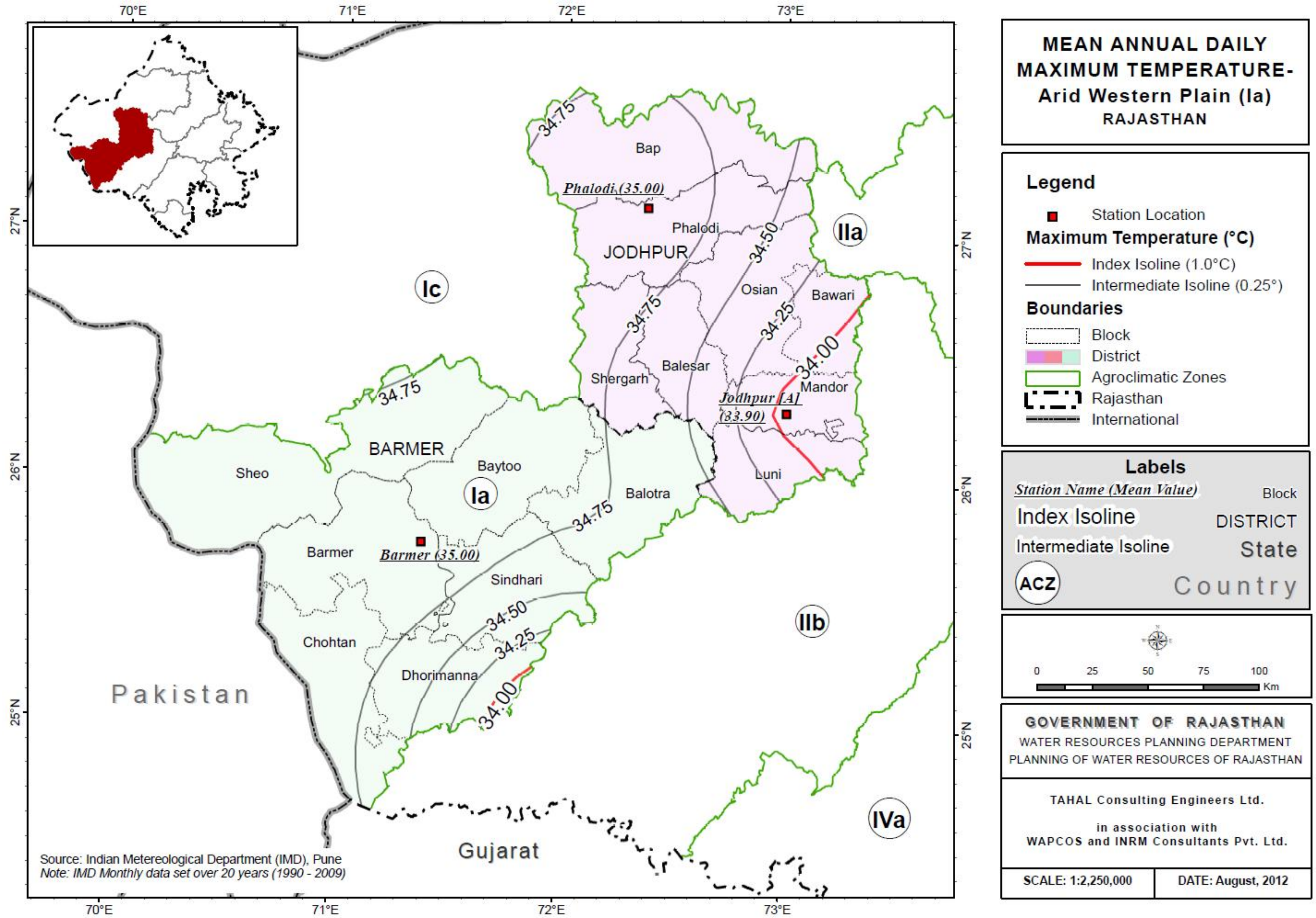
SCALE: 1:1,150,000	DATE: June, 2012



MEAN ANNUAL DAILY MAXIMUM TEMPERATURE- Arid Western Plain (Ia) RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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PLANNING OF WATER RESOURCES OF RAJASTHAN

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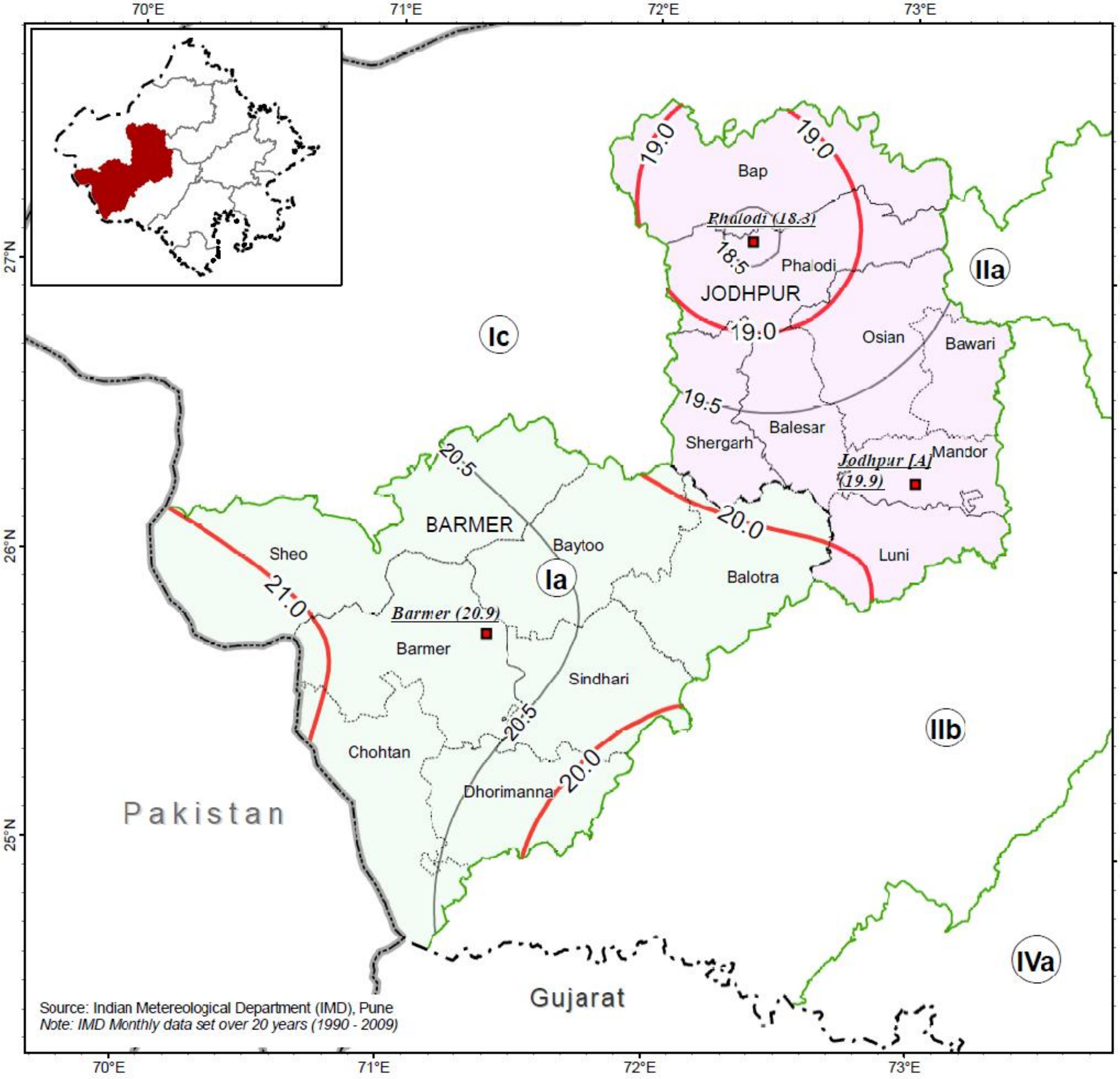
SCALE: 1:2,250,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MINIMUM TEMPERATURE- Arid Western Plain (Ia)
RAJASTHAN

Legend

■ Station Location

Minimum Temperature (°C)

Index Isoline (1.0°C)
Intermediate Isoline (0.5°C)

Boundaries

Block
District
Agroclimatic Zones
Rajasthan
International

Labels

Station Name (Mean Value) Block
Index Isoline DISTRICT
Intermediate Isoline State
ACZ Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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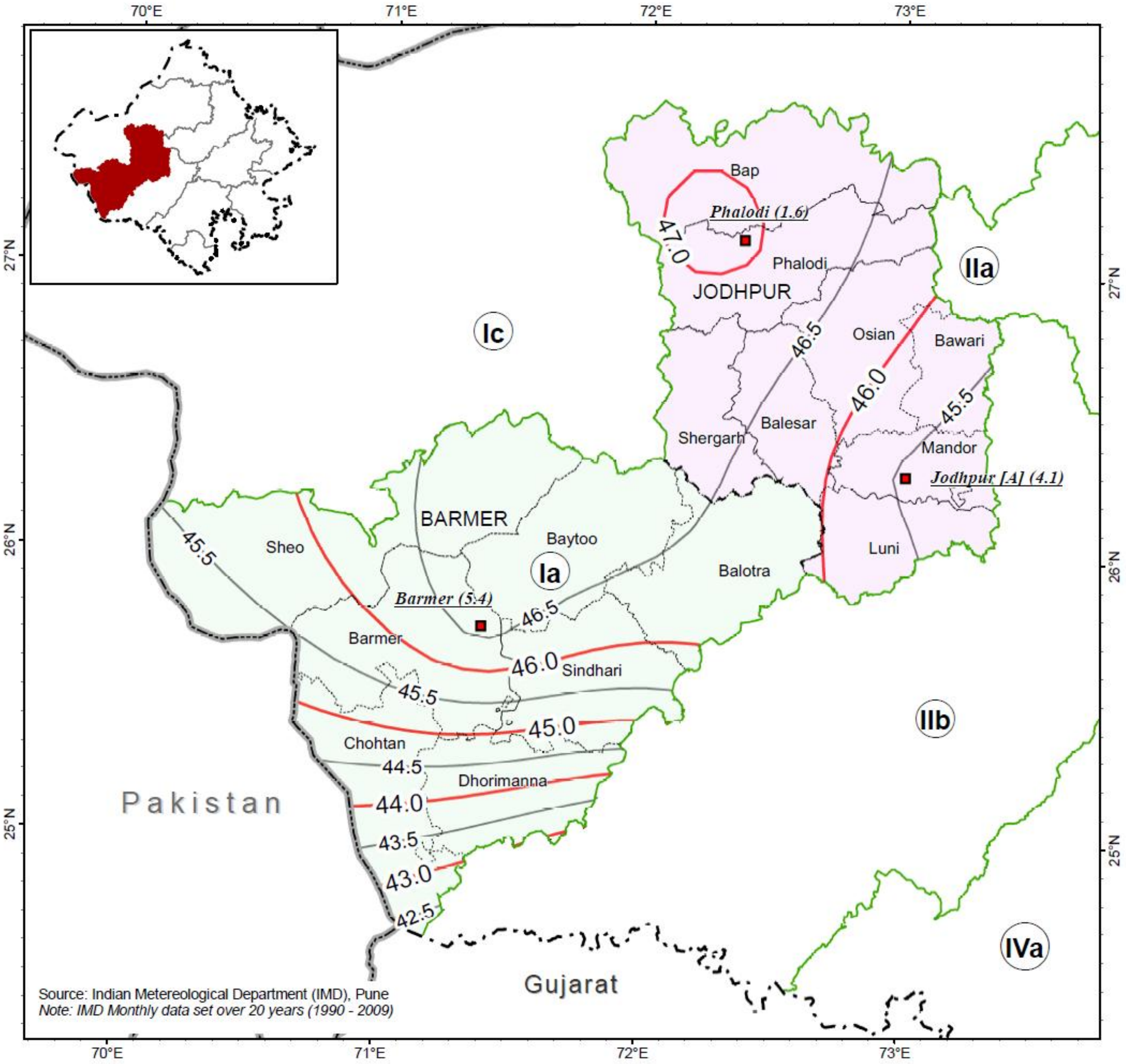
SCALE: 1:2,250,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Arid Western Plain (Ia)

RAJASTHAN

Legend

■ Station Location

Highest Maximum Temperature (°C)

Index Isoline (1.0°C)
Intermediate Isoline (0.5°C)

Boundaries

Block
District
Agroclimatic Zones
Rajasthan
International

Labels

Station Name (Mean Value) Block
Index Isoline DISTRICT
Intermediate Isoline State
ACZ Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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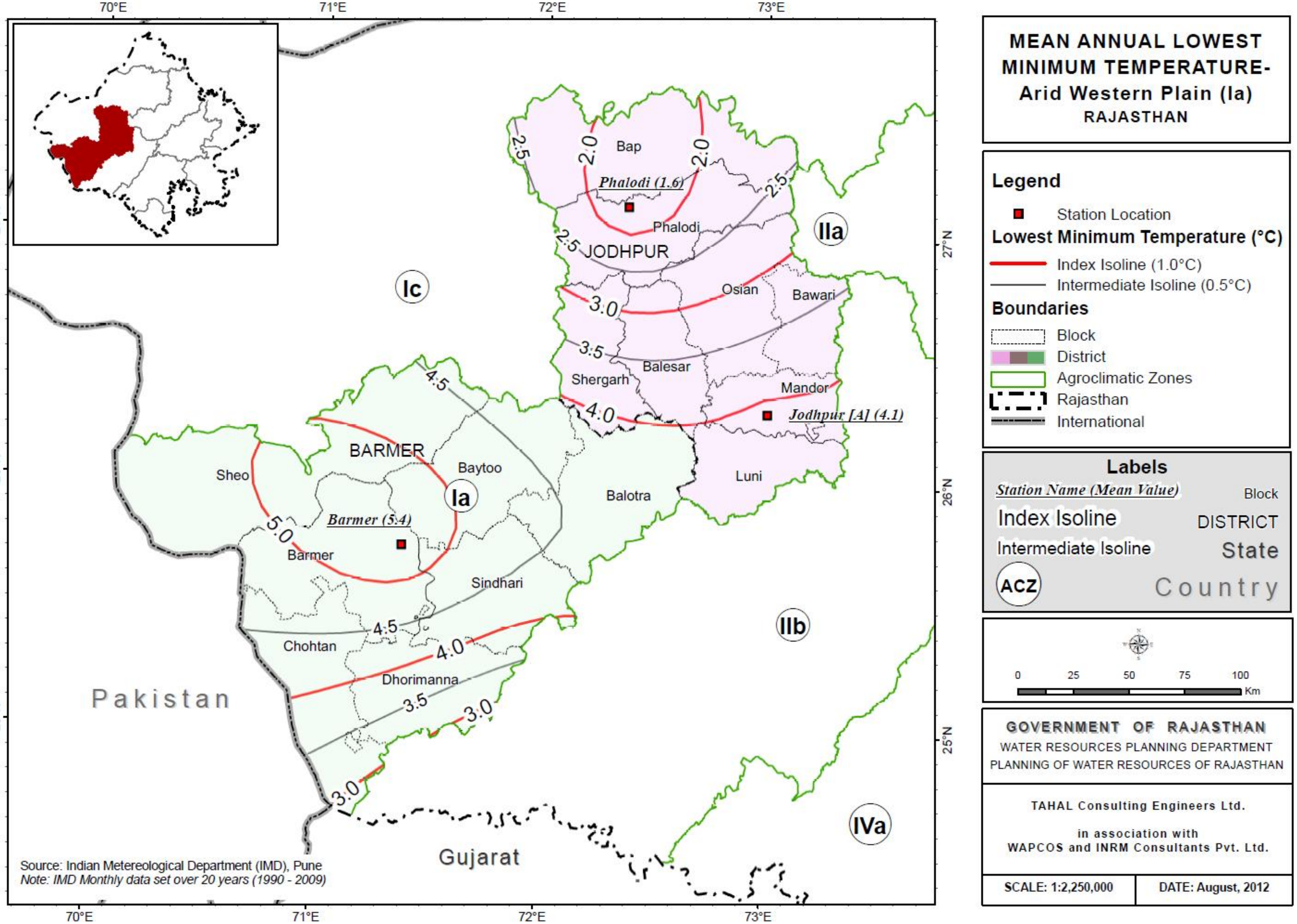
SCALE: 1:2,250,000 DATE: August, 2012

MEAN ANNUAL LOWEST MINIMUM TEMPERATURE- Arid Western Plain (Ia)

RAJASTHAN



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

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PLANNING OF WATER RESOURCES OF RAJASTHAN

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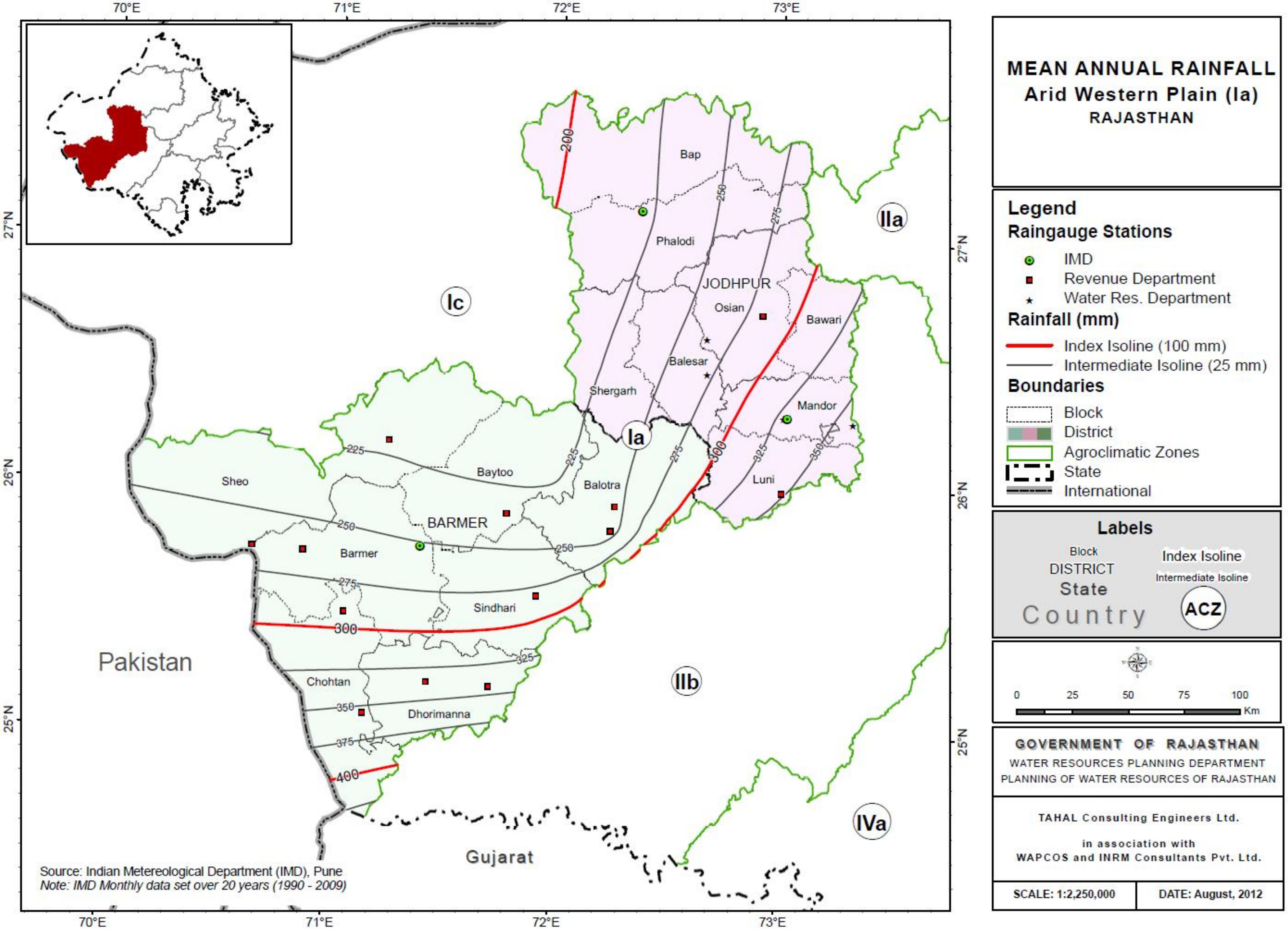
SCALE: 1:2,250,000	DATE: August, 2012


MEAN ANNUAL RAINFALL
Arid Western Plain (Ia)
RAJASTHAN
Legend
Raingauge Stations
IMD
Revenue Department
Water Res. Department
Rainfall (mm)
Index Isoline (100 mm)
Intermediate Isoline (25 mm)
Boundaries
Block
District
Agroclimatic Zones
State
International
Labels
Block
DISTRICT
State
Country
Index Isoline
Intermediate Isoline
ACZ
0
25
50
75
100
Km
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN
TAHAL Consulting Engineers Ltd.
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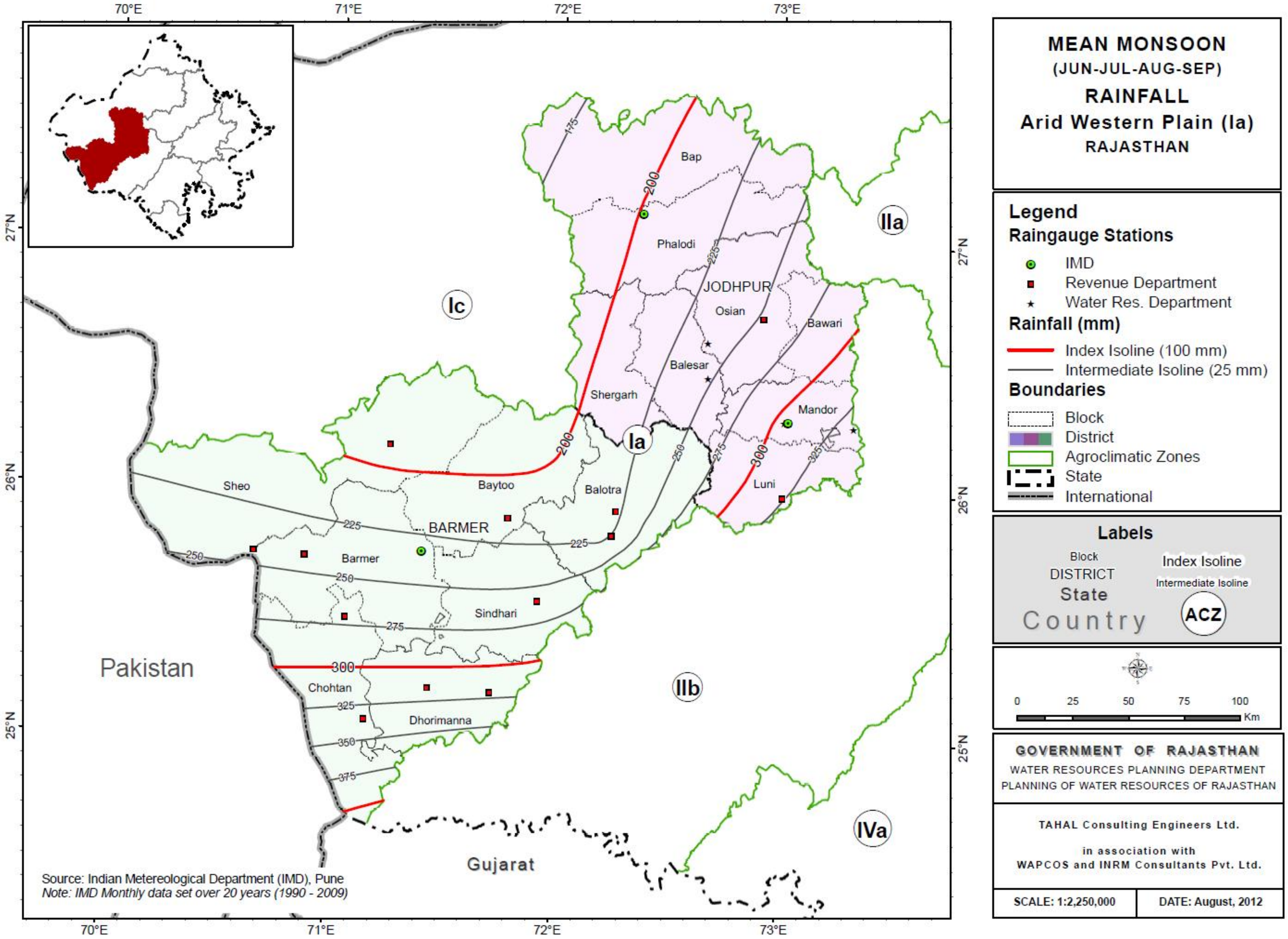
SCALE: 1:2,250,000
DATE: August, 2012
70°E
71°E
72°E
73°E
27°N
26°N
25°N
Bap
Phalodi
JODHPUR
Osian
Bawari
Balesar
Shergarh
Mandor
Luni
Ia
Ic
IIa
IIb
IVa
Sheo
Baytoo
Balotra
BARMER
Barmer
Sindhari
Chohtan
Dhorimanna
Pakistan
Gujarat
200
225
250
275
300
325
350
375
400
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN MONSOON (JUN-JUL-AUG-SEP) RAINFALL Arid Western Plain (Ia) RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

SCALE: 1:2,250,000

DATE: August, 2012

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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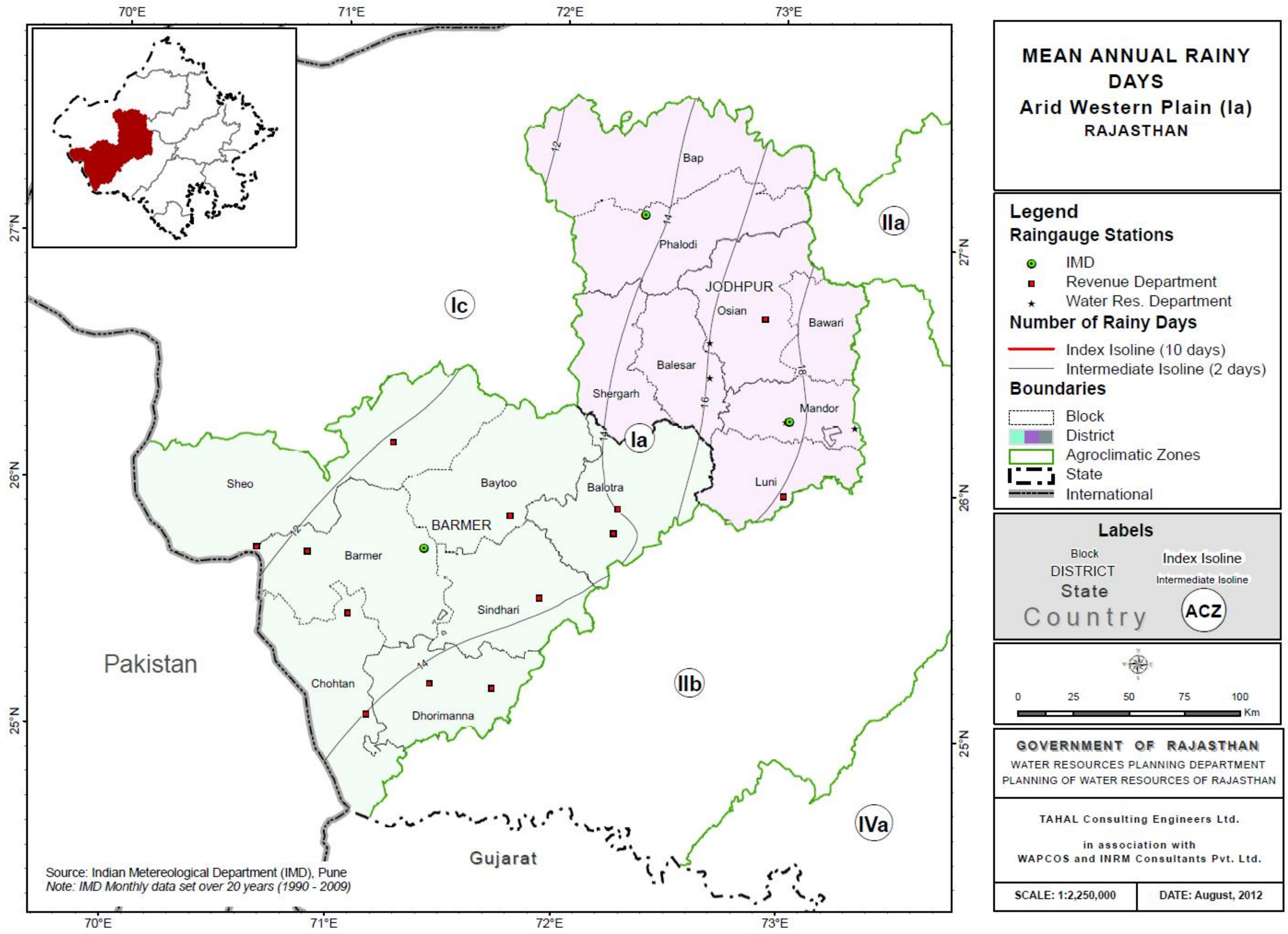
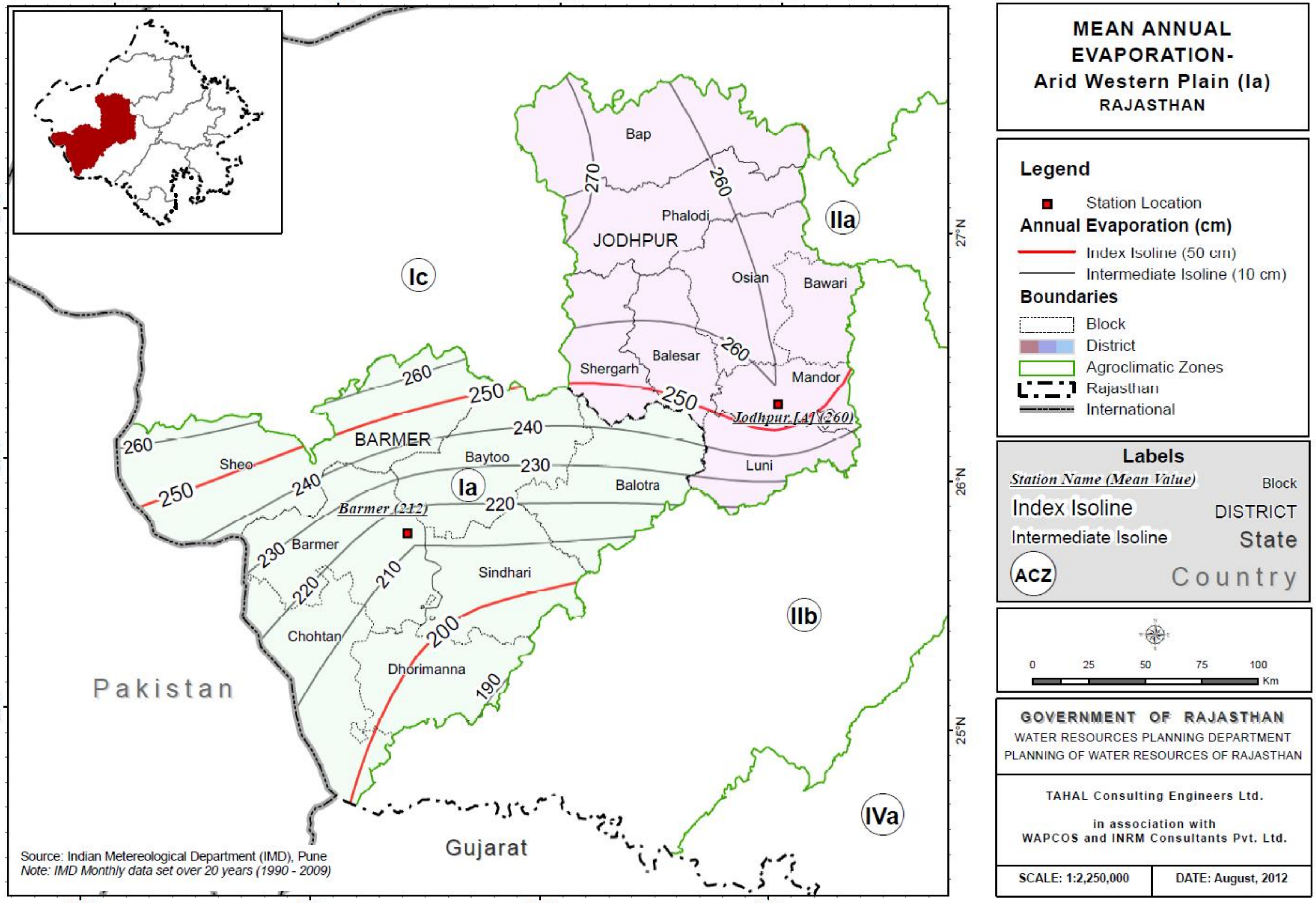


MEAN ANNUAL RAINY DAYS
Arid Western Plain (Ia)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL EVAPORATION-
Arid Western Plain (Ia)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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PLANNING OF WATER RESOURCES OF RAJASTHAN

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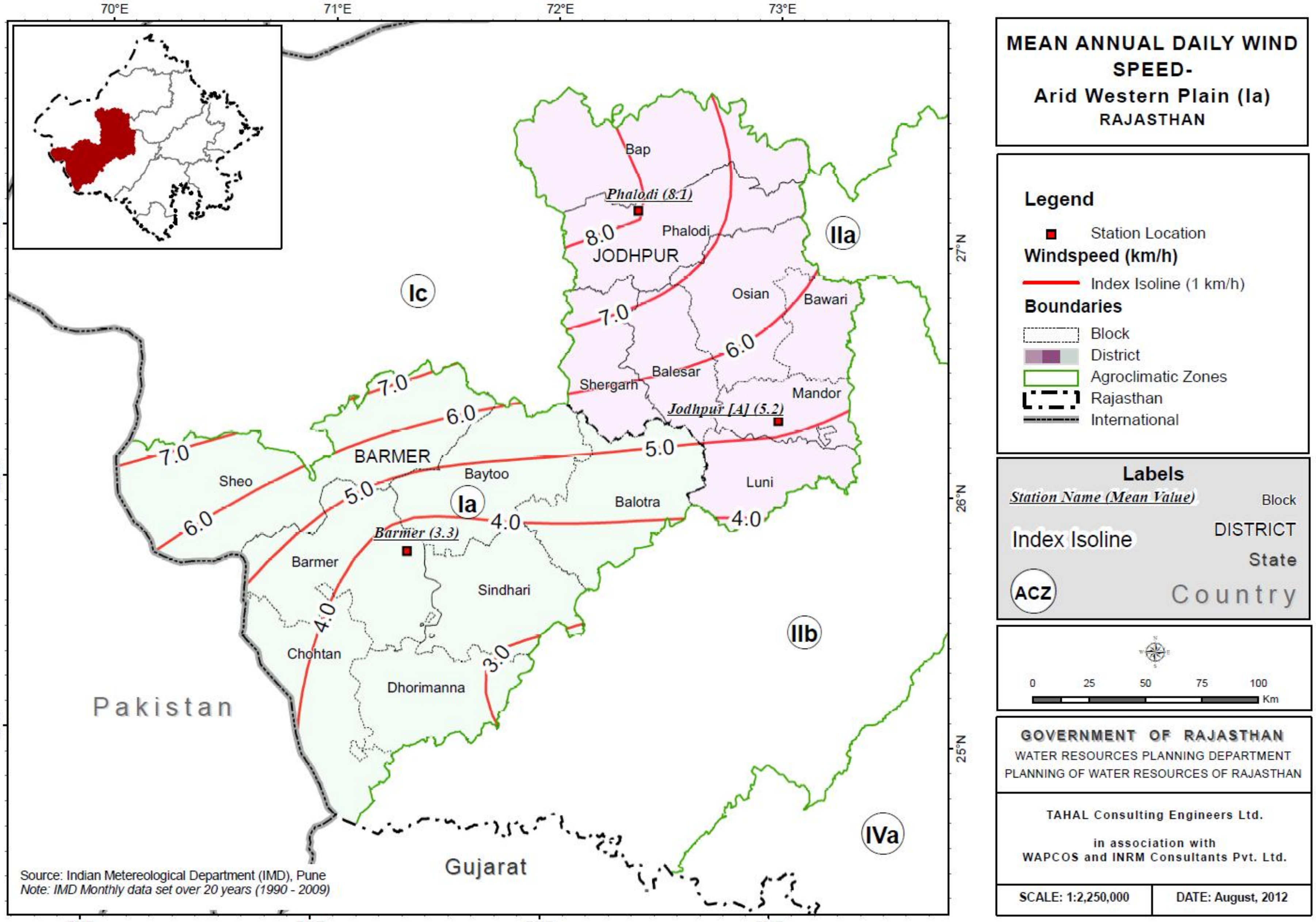
SCALE: 1:2,250,000	DATE: August, 2012


MEAN ANNUAL DAILY WIND SPEED-
Arid Western Plain (Ia)
RAJASTHAN
Legend
Station Location
Windspeed (km/h)
Index Isoline (1 km/h)
Boundaries
Block
District
Agroclimatic Zones
Rajasthan
International
Labels
Station Name (Mean Value)
Block
DISTRICT
Index Isoline
State
ACZ
Country
0
25
50
75
100
Km
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN
TAHAL Consulting Engineers Ltd.
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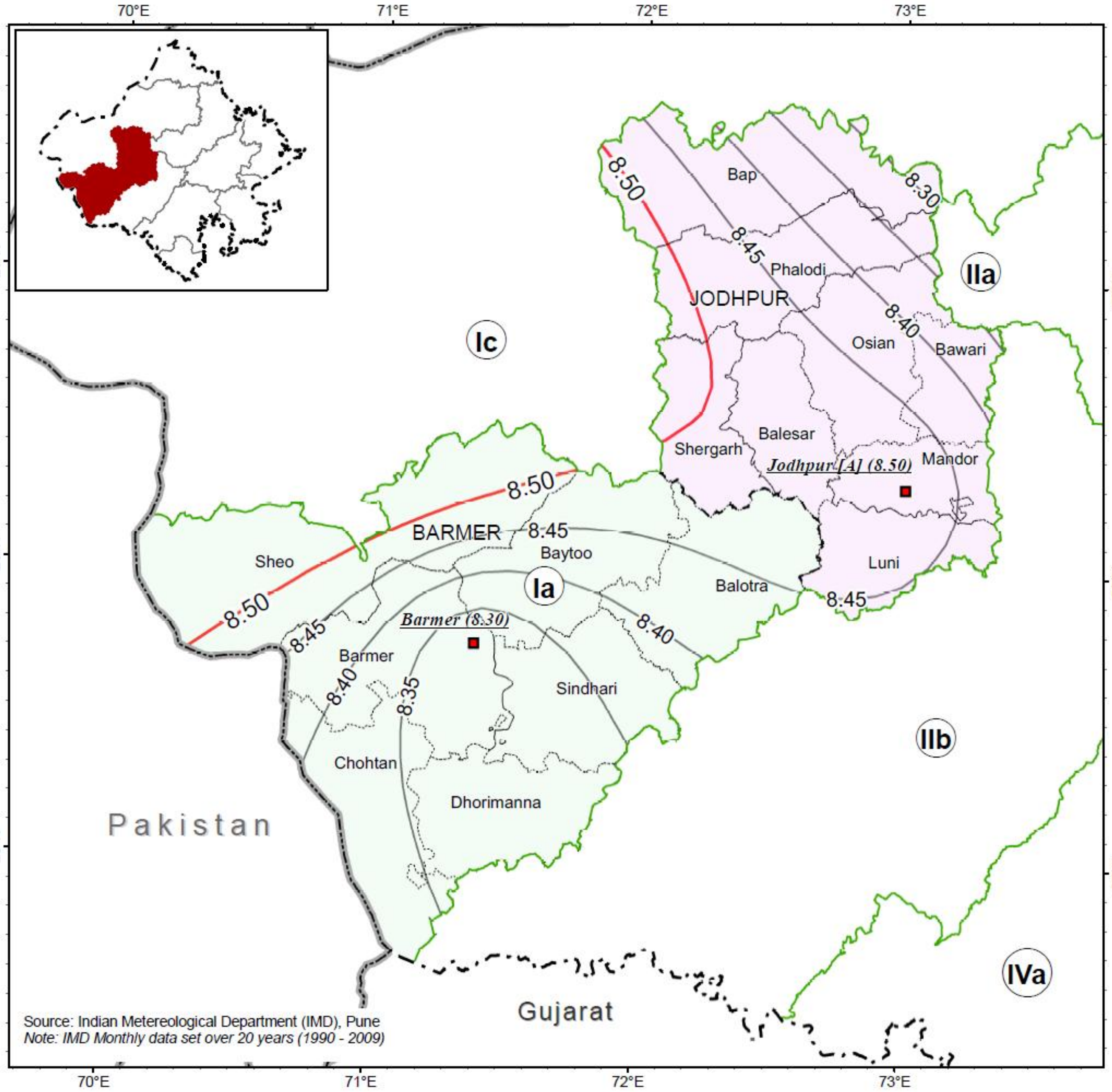
SCALE: 1:2,250,000
DATE: August, 2012
70°E
71°E
72°E
73°E
27°N
26°N
25°N
Bap
Phalodi (8.1)
8.0
Phalodi
JODHPUR
IIa
Ic
Osian
Bawari
7.0
6.0
Balesar
Shergarh
Mandor
Jodhpur [A] (5.2)
7.0
6.0
7.0
BARMER
5.0
Sheo
Baytoo
5.0
Ia
Balotra
Luni
4.0
4.0
6.0
Barmer (3.3)
Barmer
Sindhari
4.0
Chohtan
3.0
IIb
Dhorimanna
Pakistan
IVa
Gujarat
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY SUNSHINE HOURS- Arid Western Plain (Ia)
RAJASTHAN

Legend

■ Station Location

Sunshine Hours

- Index Isoline (30 minute)
- Intermediate Isoline (3 minute)

Boundaries

- Block
- District
- Agroclimatic Zones
- Rajasthan
- International

Labels

Station Name (Mean Value) — Block
Index Isoline — DISTRICT
Intermediate Isoline — State
ACZ — Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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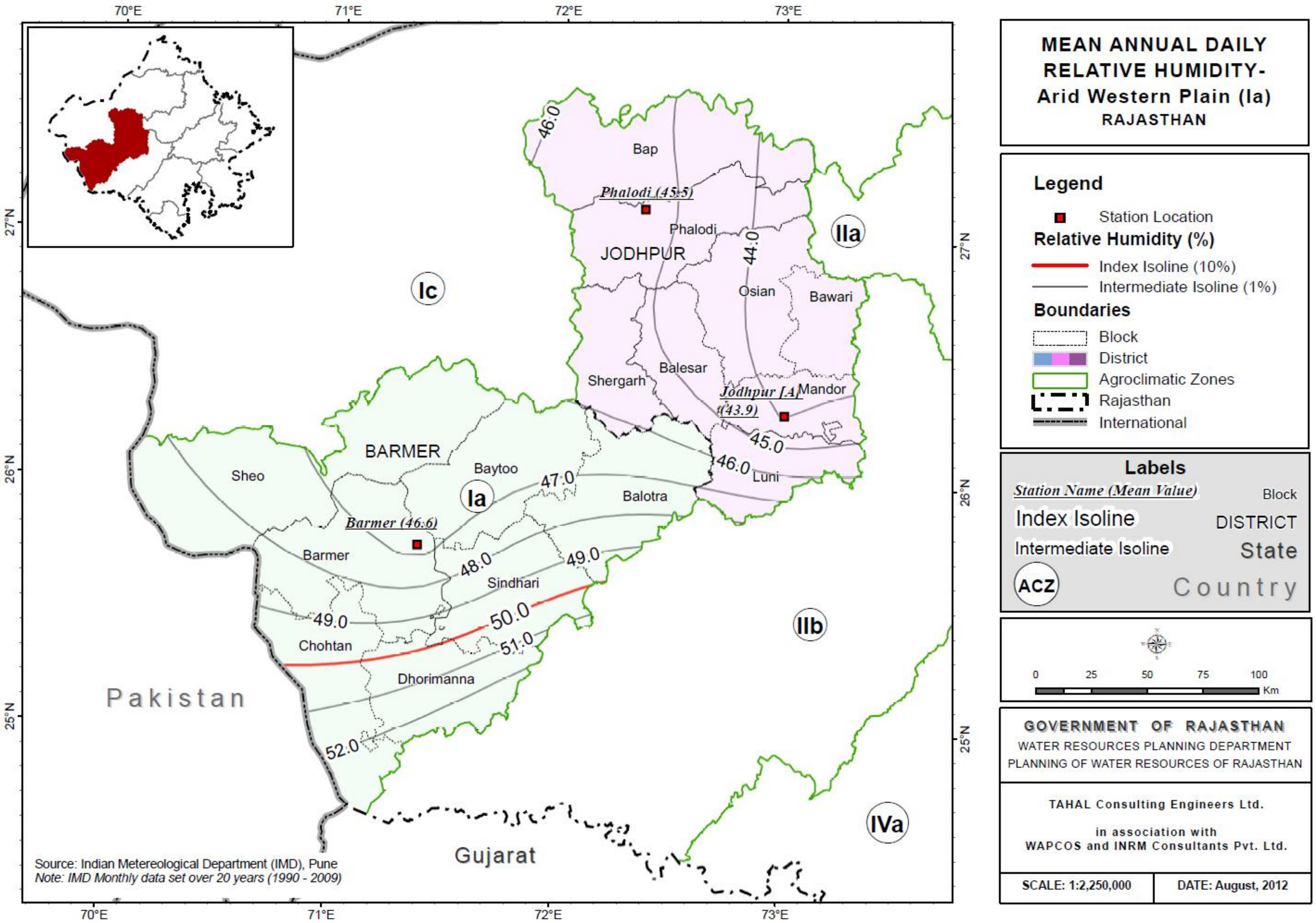
SCALE: 1:2,250,000	DATE: August, 2012



MEAN ANNUAL DAILY RELATIVE HUMIDITY- Arid Western Plain (Ia)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

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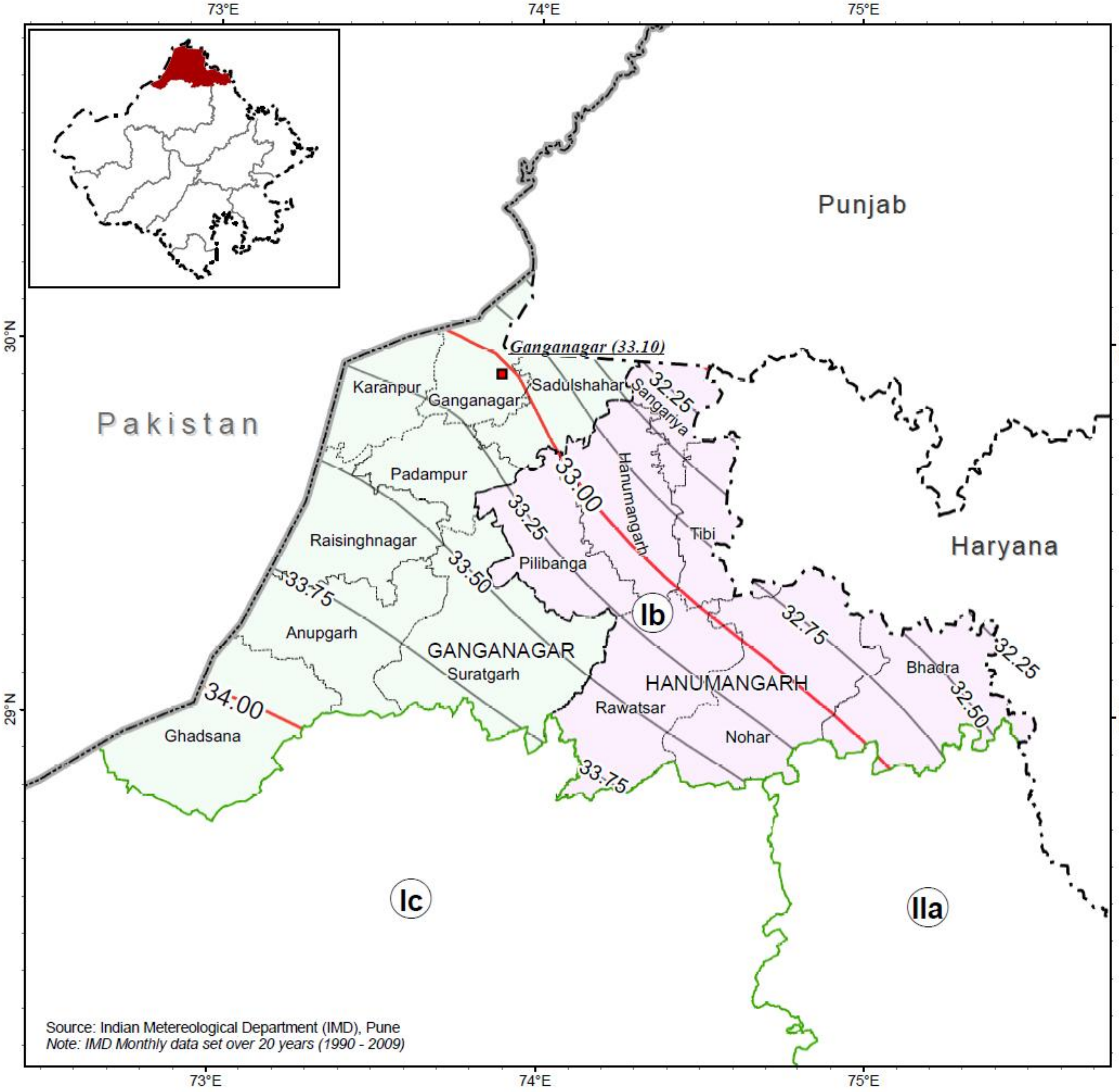
SCALE: 1:2,250,000 DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE

Irrigated North-Western Plain (Ib)

RAJASTHAN

Legend

■ Station Location

Maximum Temperature (°C)

Index Isoline (1.0°C)

Intermediate Isoline (0.25°)

Boundaries

Block

District

Agroclimatic Zones

State

International

Labels

Station Name (Mean Value) — Block

Index Isoline — DISTRICT

Intermediate Isoline — State

ACZ — Country

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
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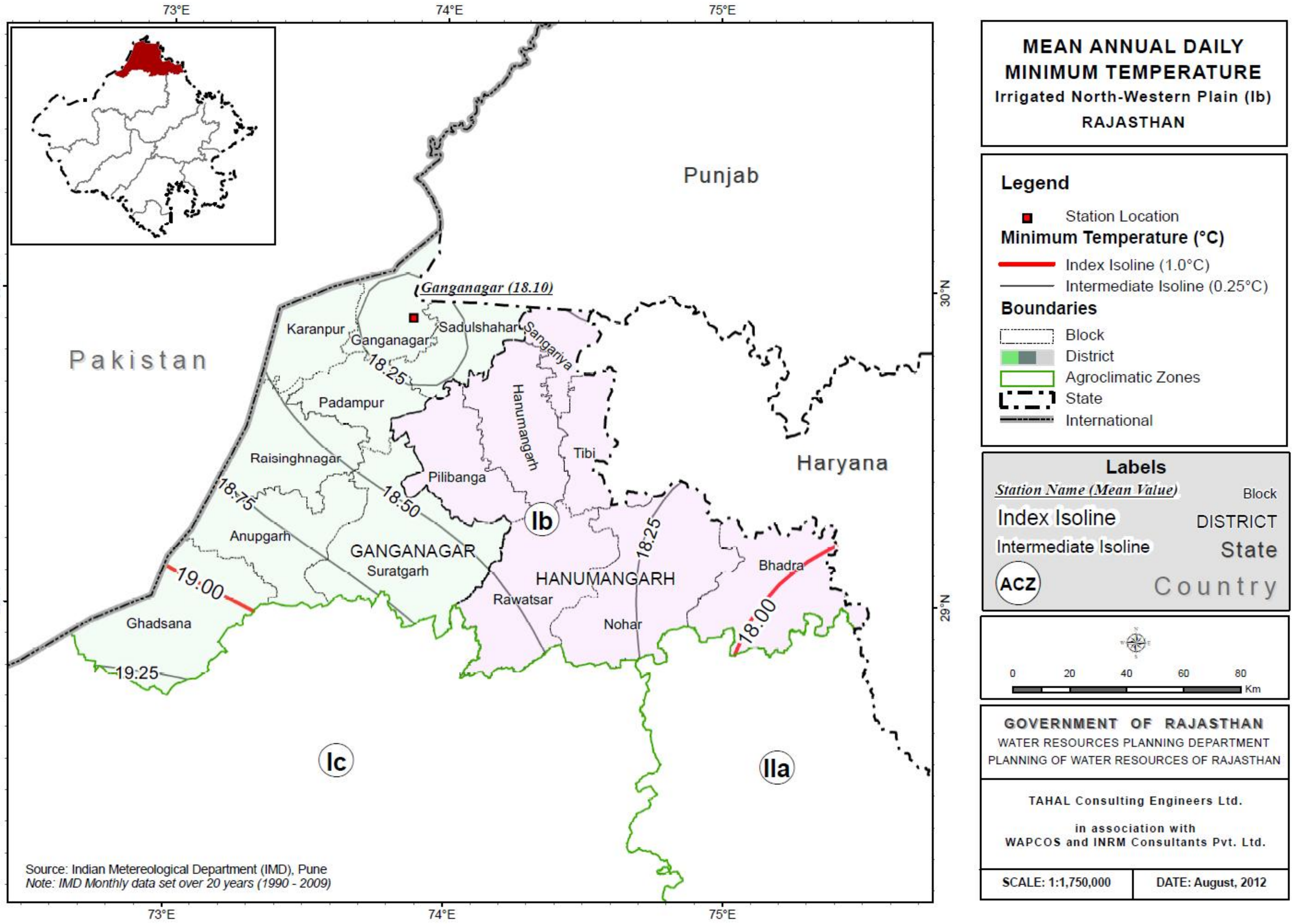
SCALE: 1:1,750,000 | DATE: August, 2012

MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Irrigated North-Western Plain (Ib)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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PLANNING OF WATER RESOURCES OF RAJASTHAN

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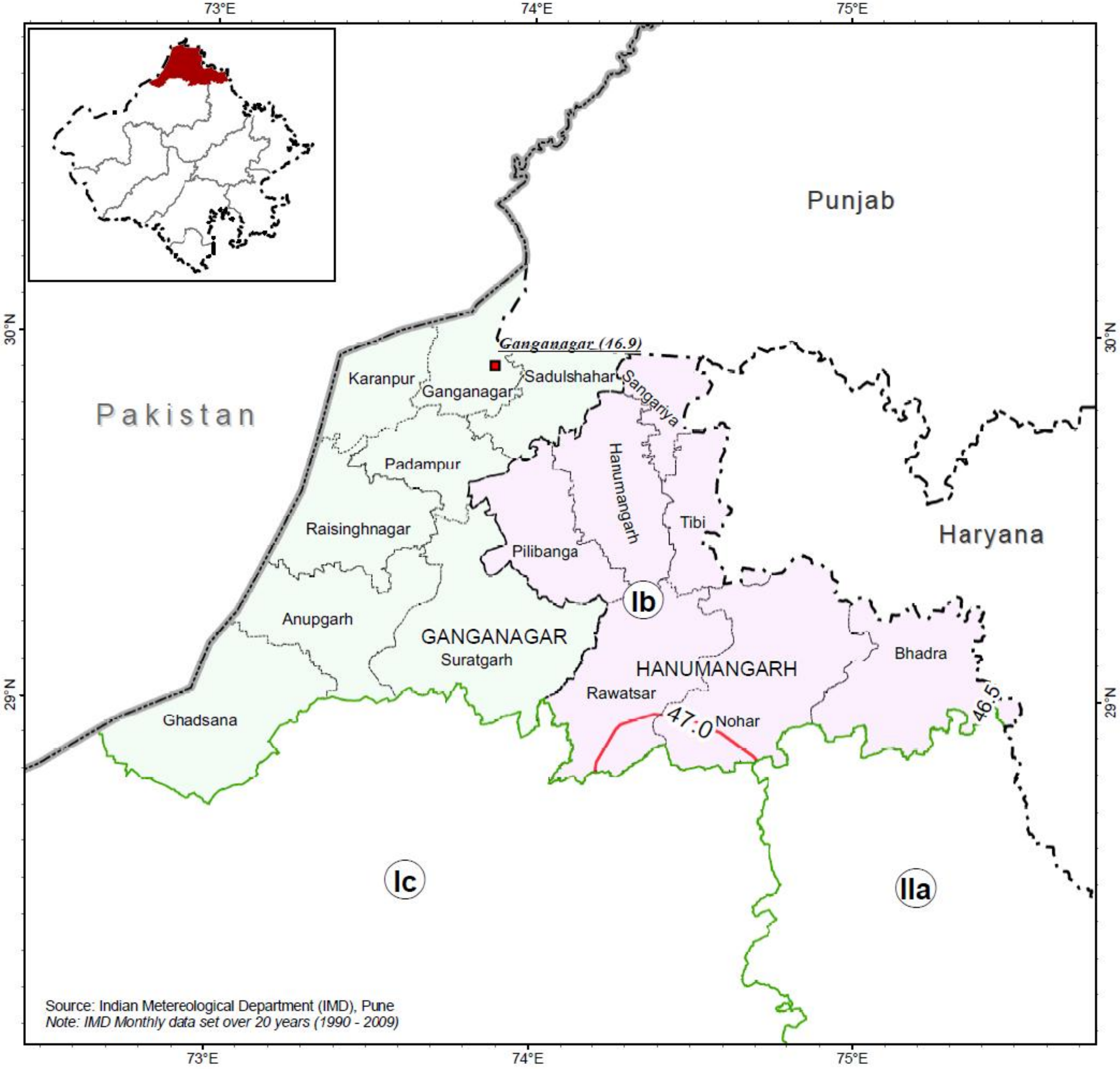
SCALE: 1:1,750,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE-
Irrigated North-Western Plain (Ib)
RAJASTHAN

Legend

■ Station Location

Highest Maximum Temperature (°C)

Index Isoline (1.0°C)

Boundaries

Block
District
Agroclimatic Zones
State
International

Labels

Station Name (Mean Value)
Block
Index Isoline
DISTRICT
State
ACZ
Country

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
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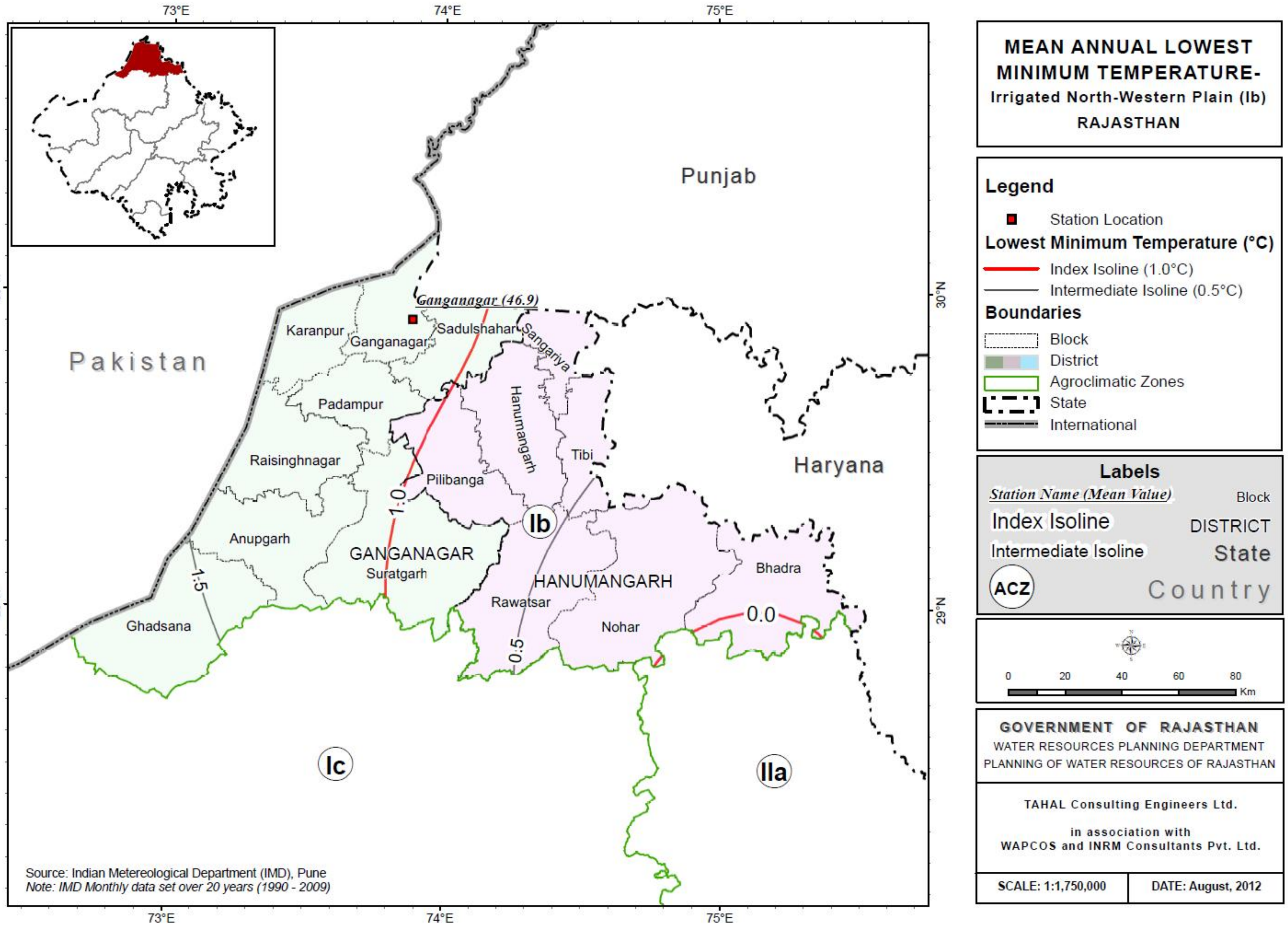
SCALE: 1:1,750,000	DATE: August, 2012



MEAN ANNUAL LOWEST MINIMUM TEMPERATURE-
Irrigated North-Western Plain (Ib)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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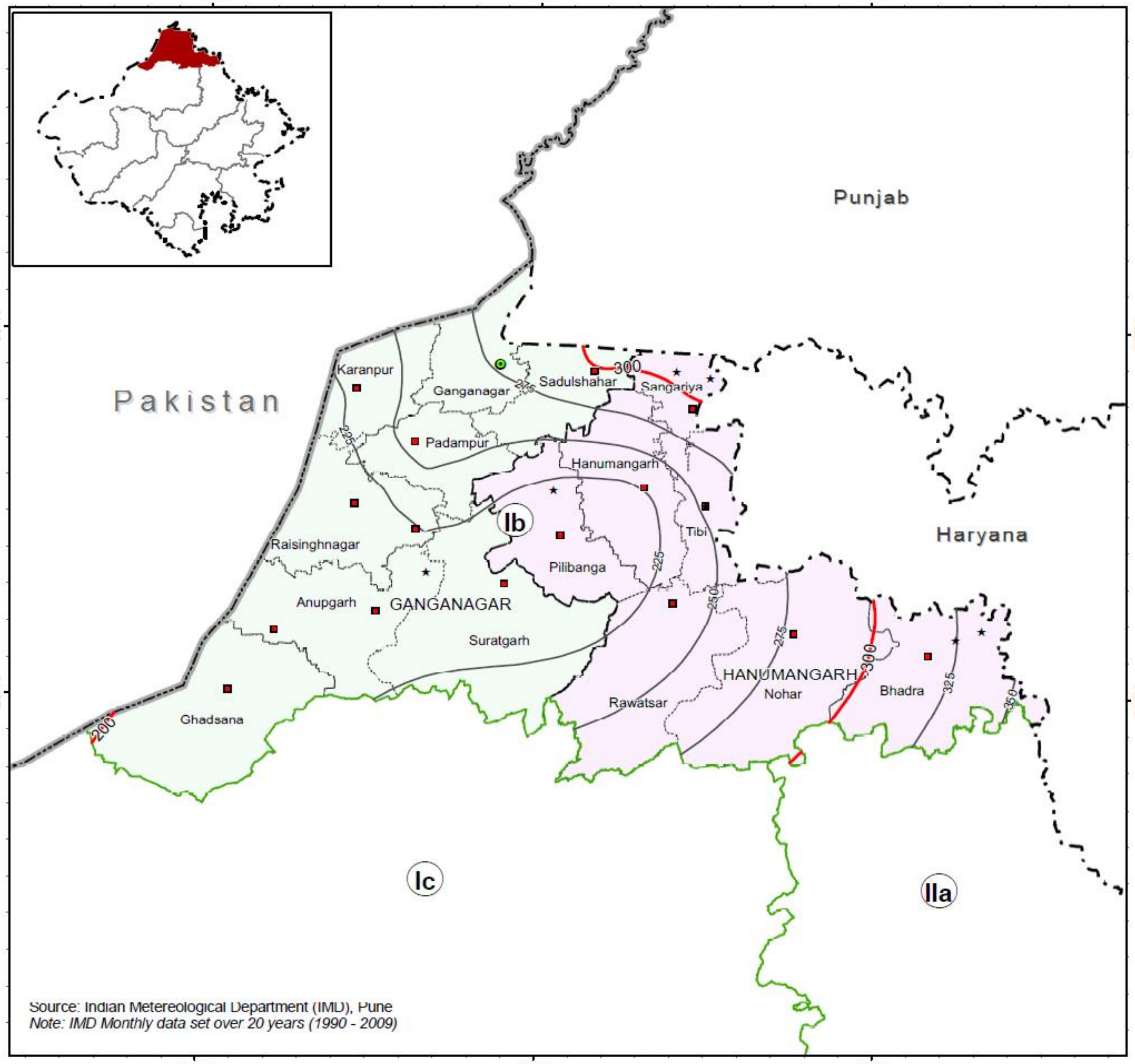
SCALE: 1:1,750,000
DATE: August, 2012

MEAN ANNUAL RAINFALL
Irrigated North-Western Plain (Ib)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)

- Index Isoline (100 mm)
- Intermediate Isoline (25 mm)

Boundaries

- Block
- District
- Agroclimatic Zones
- State
- International

Labels

Block
DISTRICT
State
Country
Index Isoline
Intermediate Isoline
ACZ

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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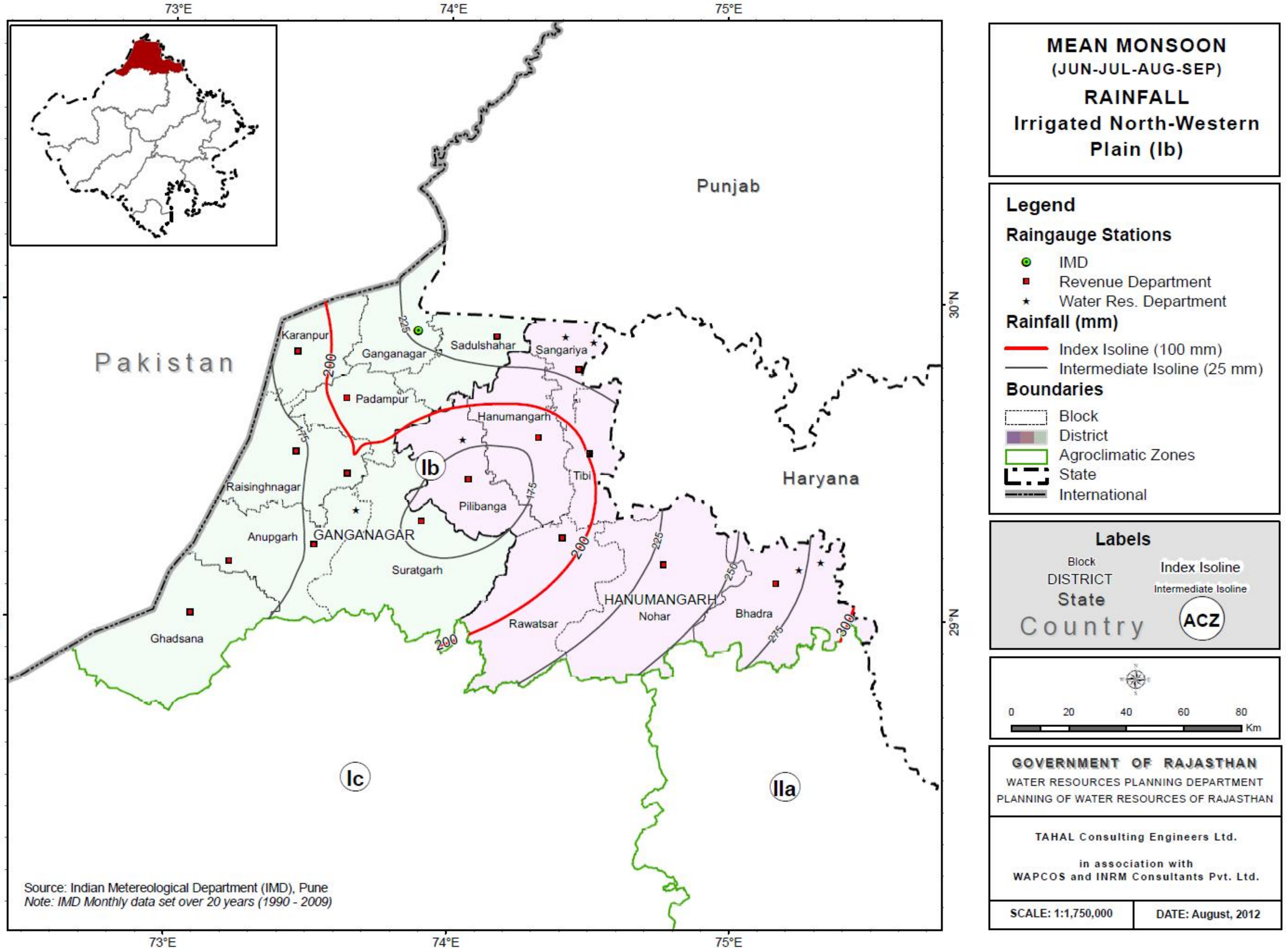
SCALE: 1:1,750,000
DATE: August, 2012

MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Irrigated North-Western Plain (Ib)



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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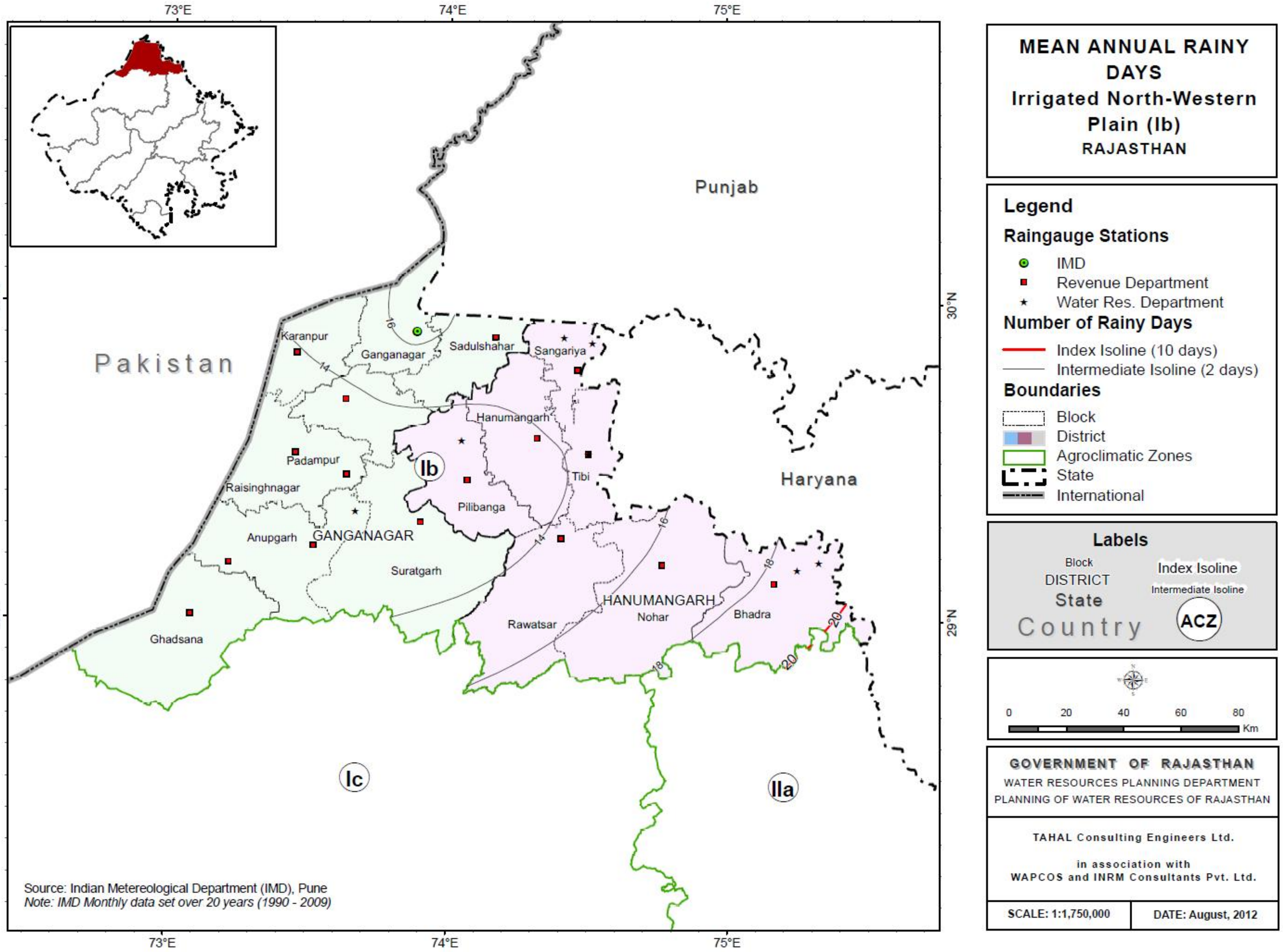
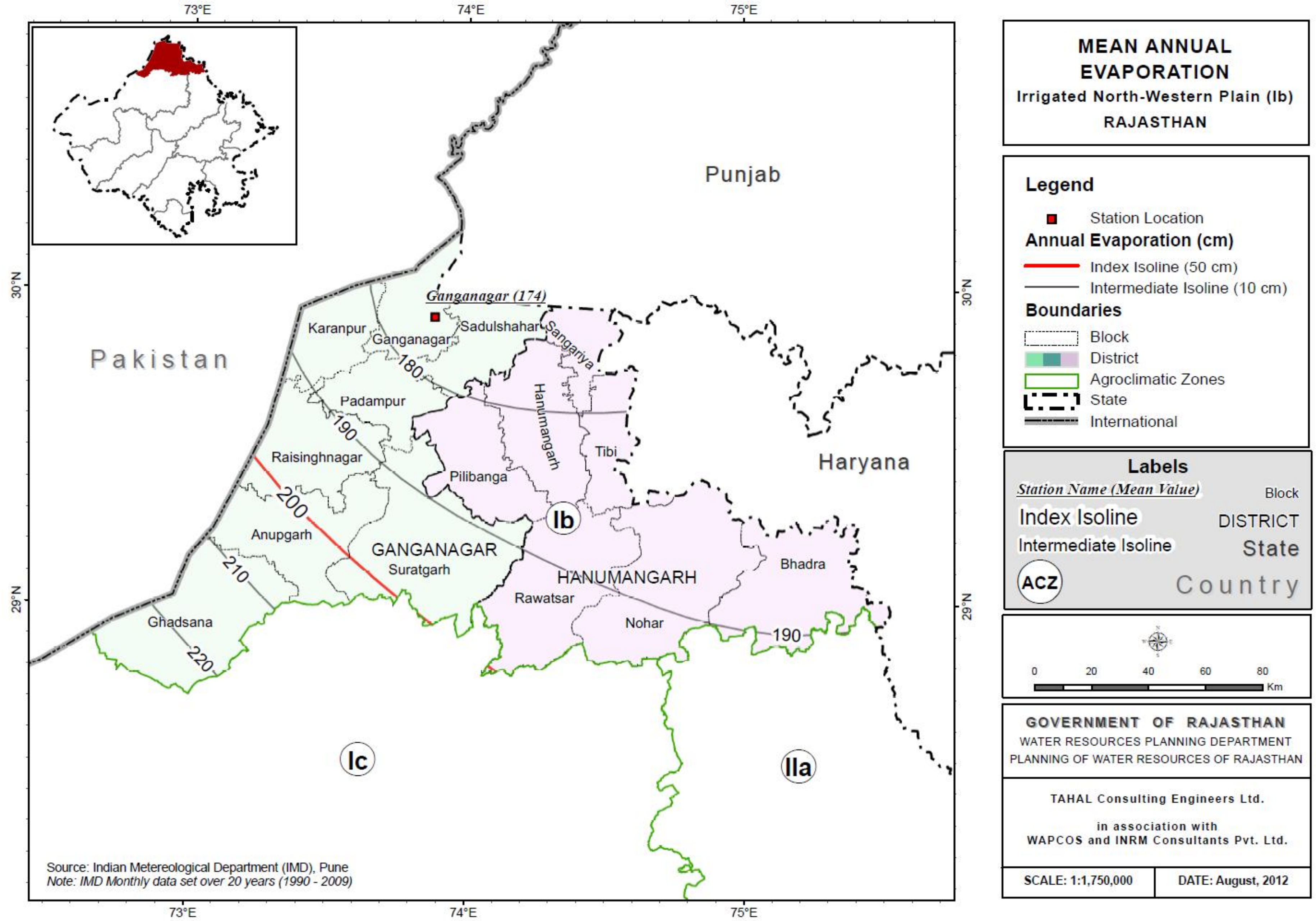
SCALE: 1:1,750,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL EVAPORATION
Irrigated North-Western Plain (Ib)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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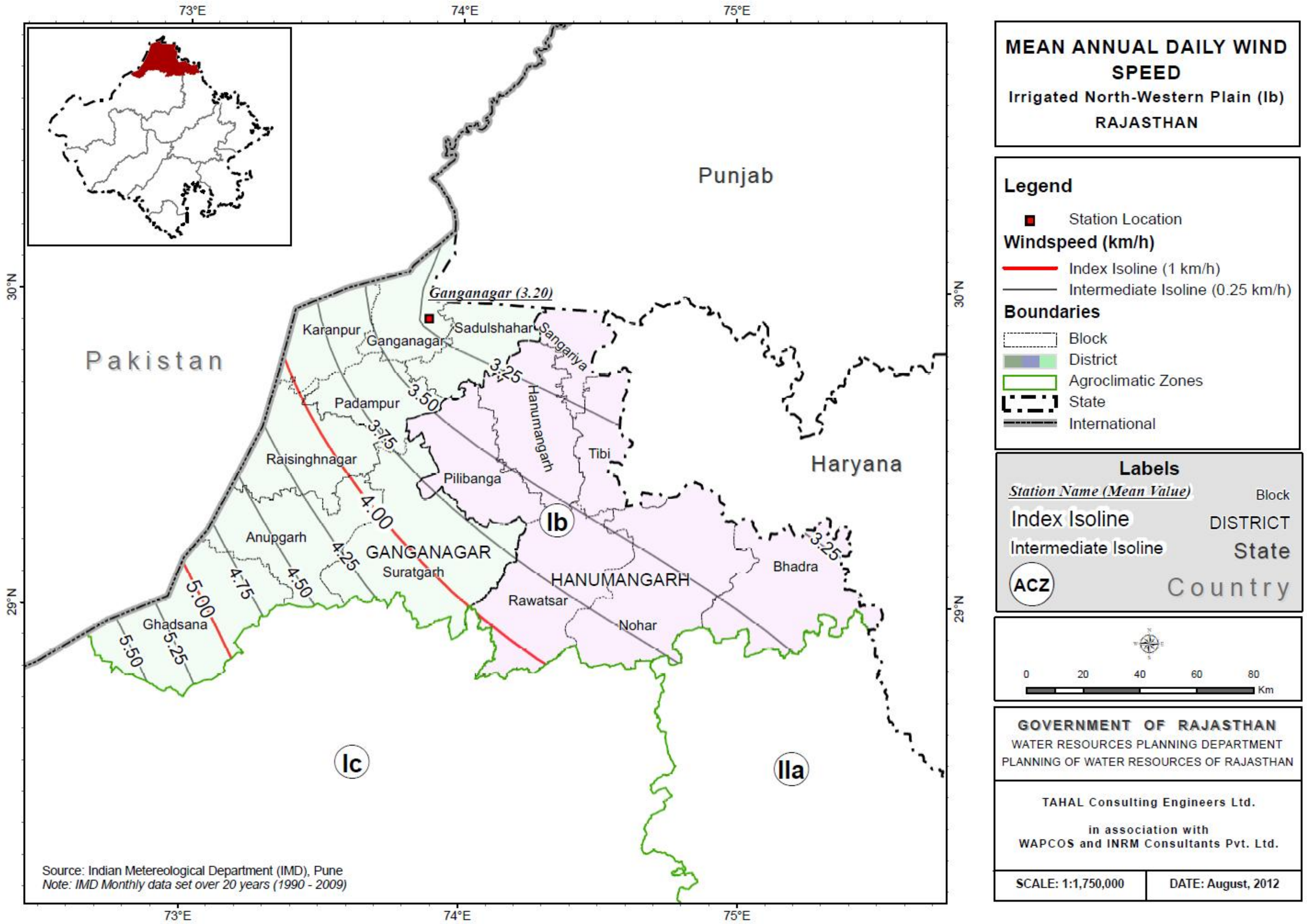
SCALE: 1:1,750,000	DATE: August, 2012



MEAN ANNUAL DAILY WIND SPEED

Irrigated North-Western Plain (Ib)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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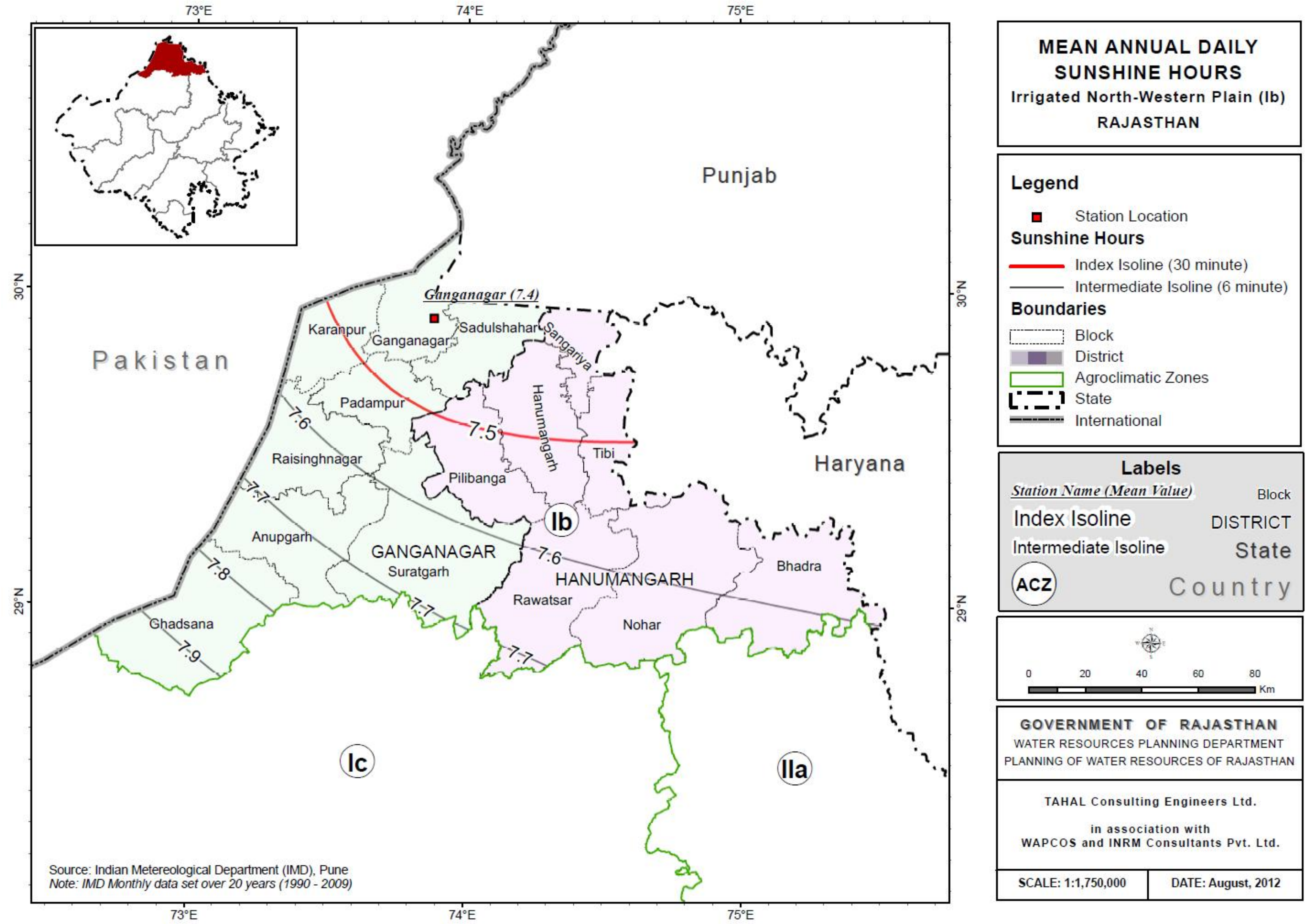
SCALE: 1:1,750,000
DATE: August, 2012



MEAN ANNUAL DAILY SUNSHINE HOURS
Irrigated North-Western Plain (Ib)
RAJASTHAN

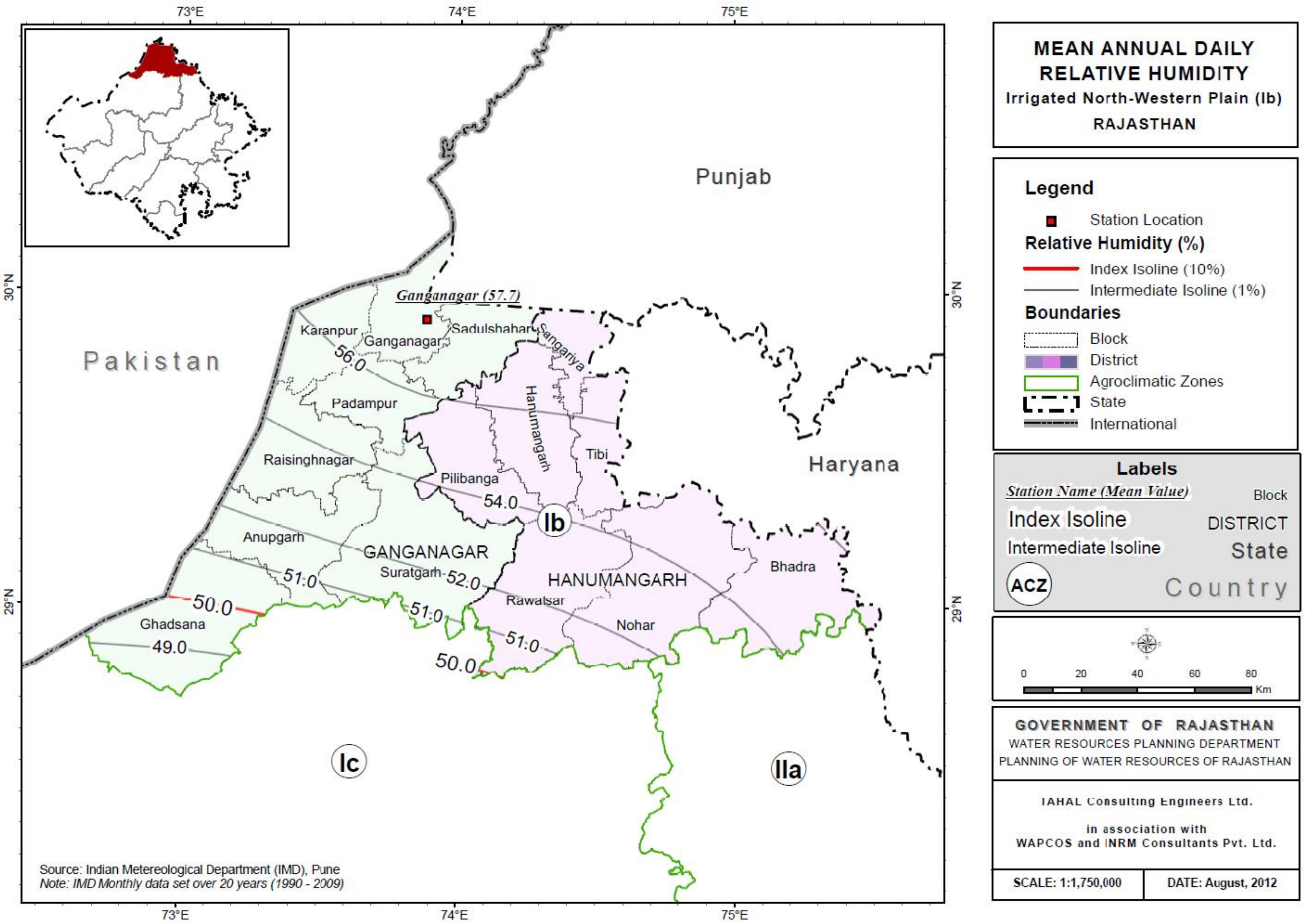
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

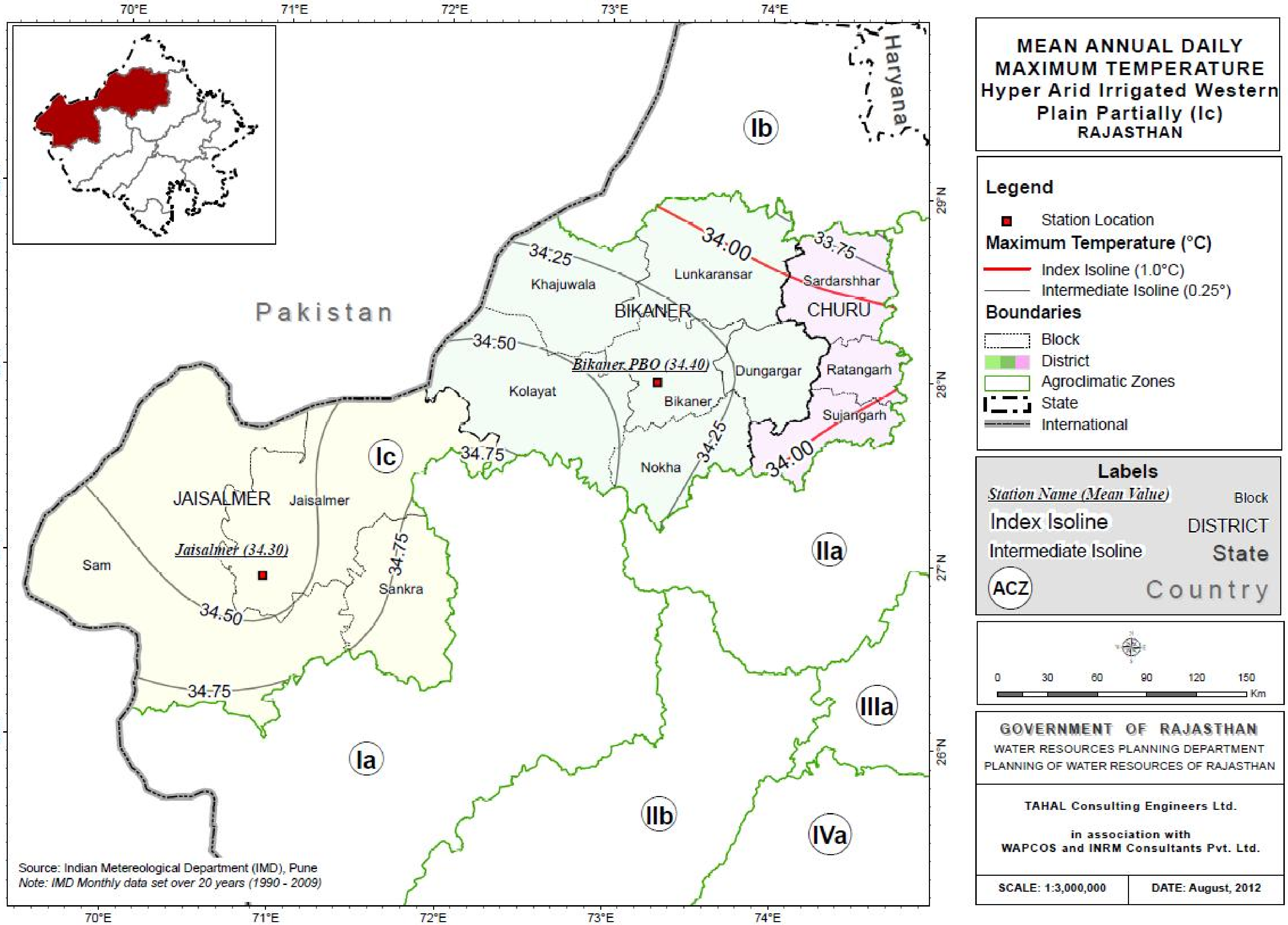
TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,750,000
DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

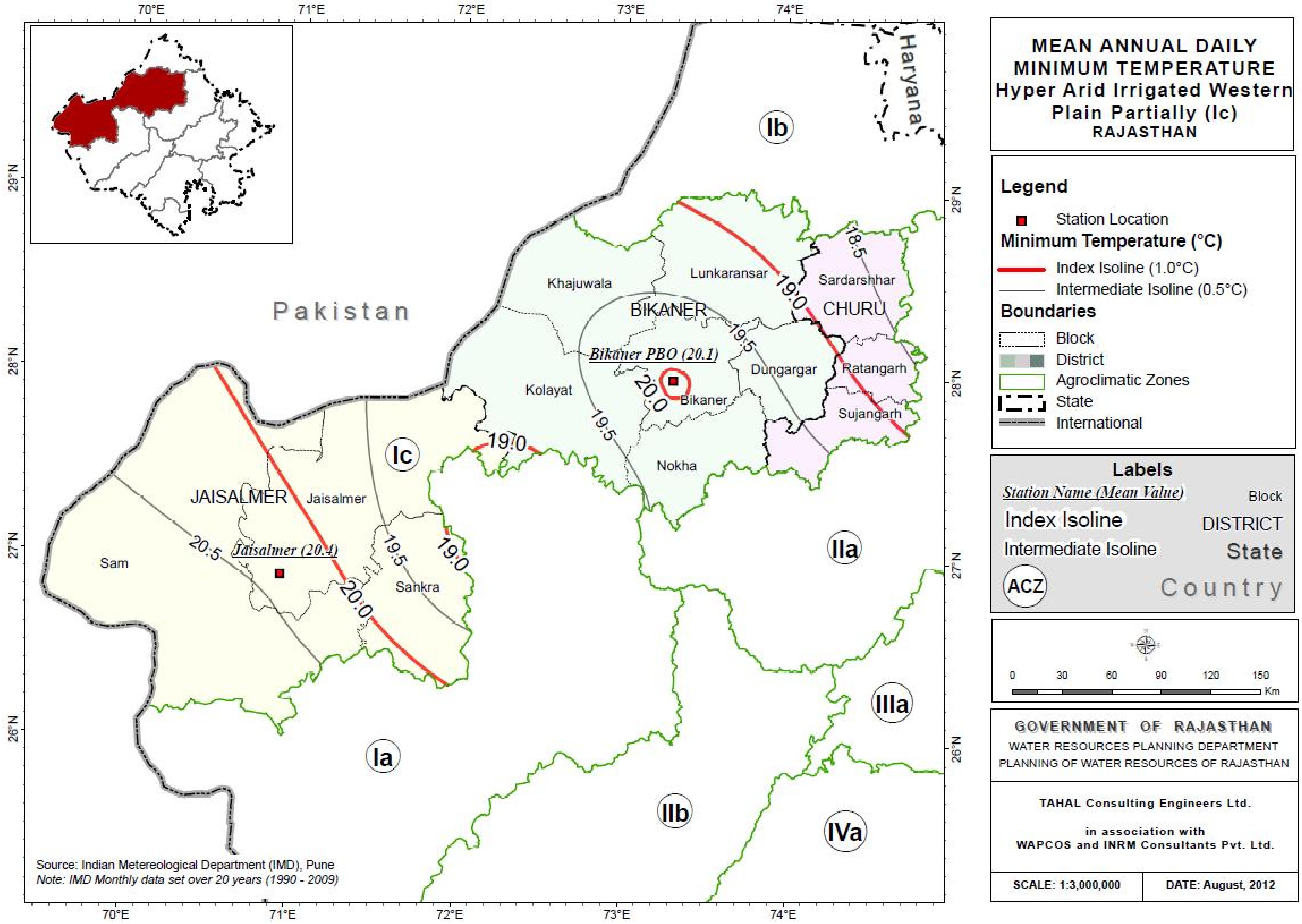
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:3,000,000

DATE: August, 2012



MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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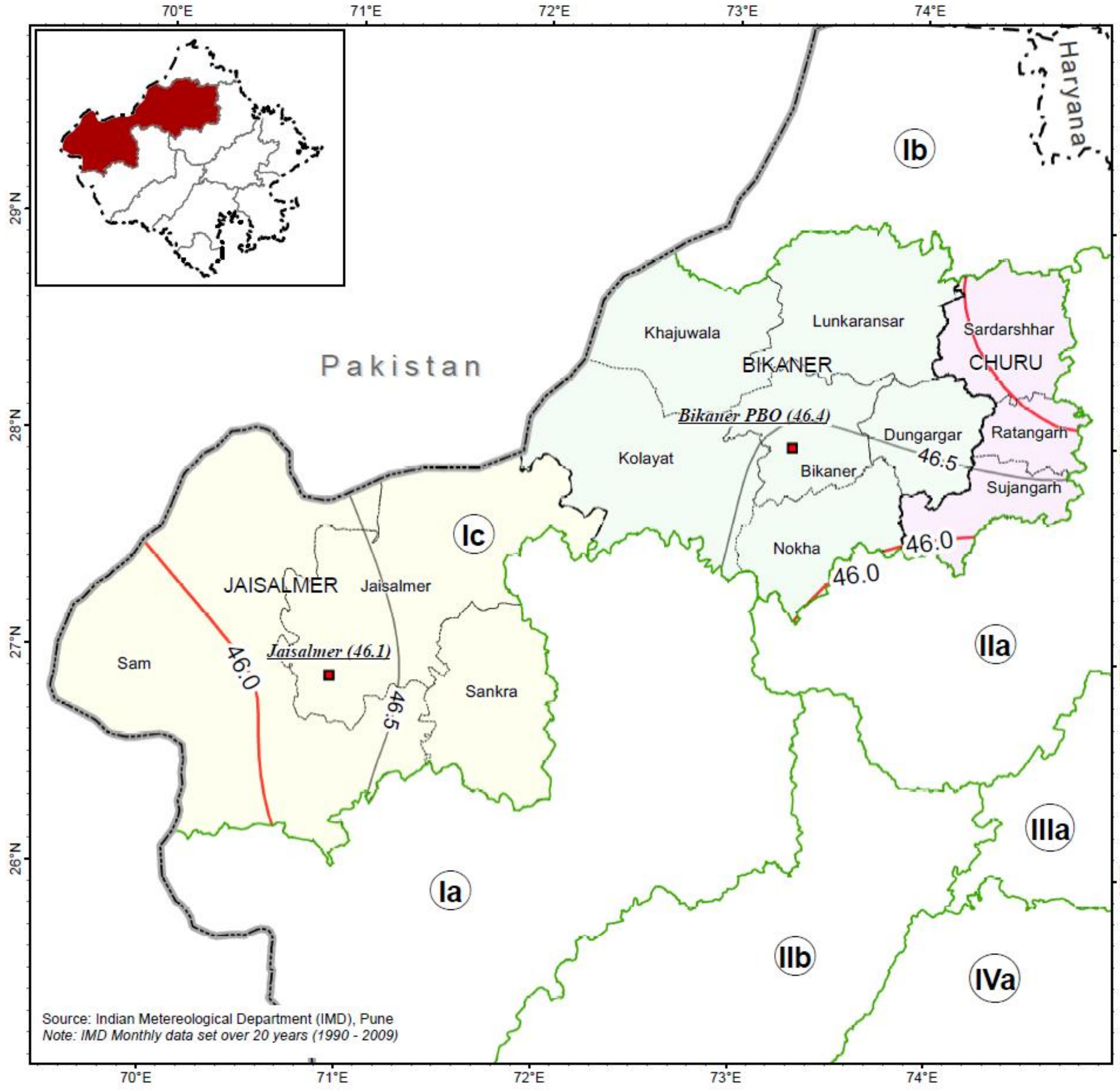
SCALE: 1:3,000,000

DATE: August, 2012

MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE-
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

■ Station Location

Highest Maximum Temperature (°C)

- Index Isoline (1.0°C)
- Intermediate Isoline (0.5°C)

Boundaries

- Block
- District
- Agroclimatic Zones
- State
- International

Labels

Station Name (Mean Value) Block
Index Isoline DISTRICT
Intermediate Isoline State
ACZ Country

0 30 60 90 120 150 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
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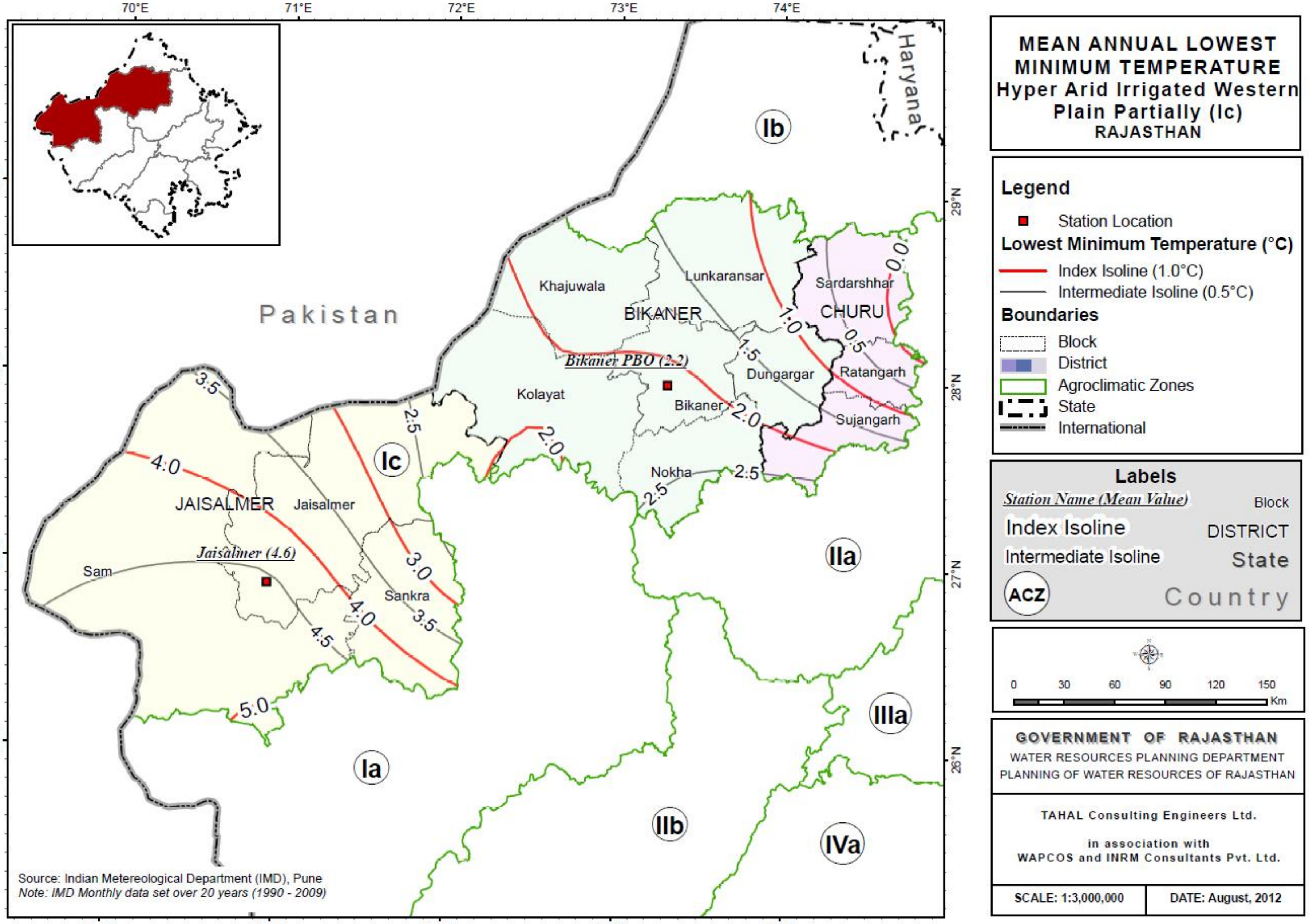
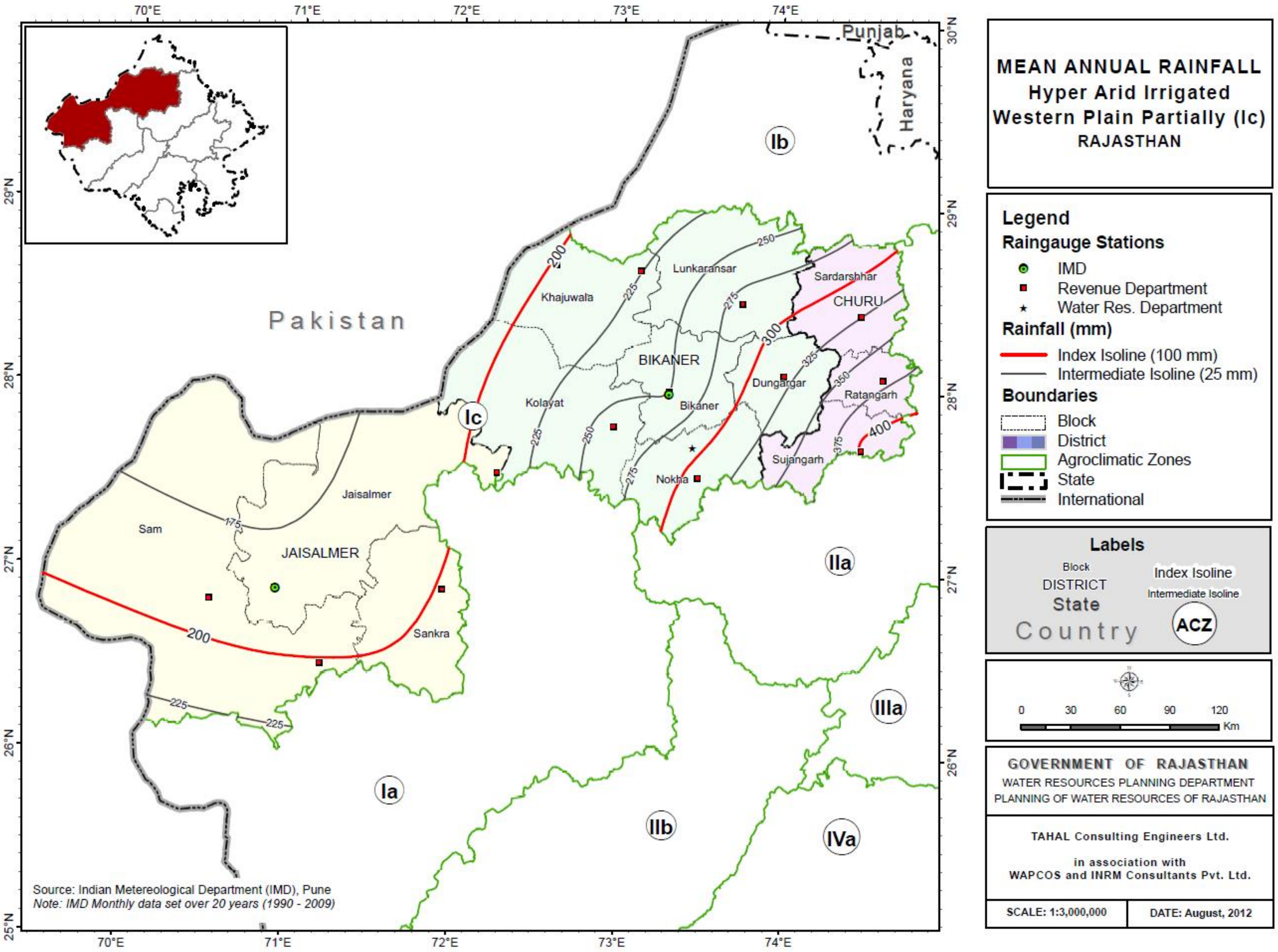
SCALE: 1:3,000,000 DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL RAINFALL
Hyper Arid Irrigated
Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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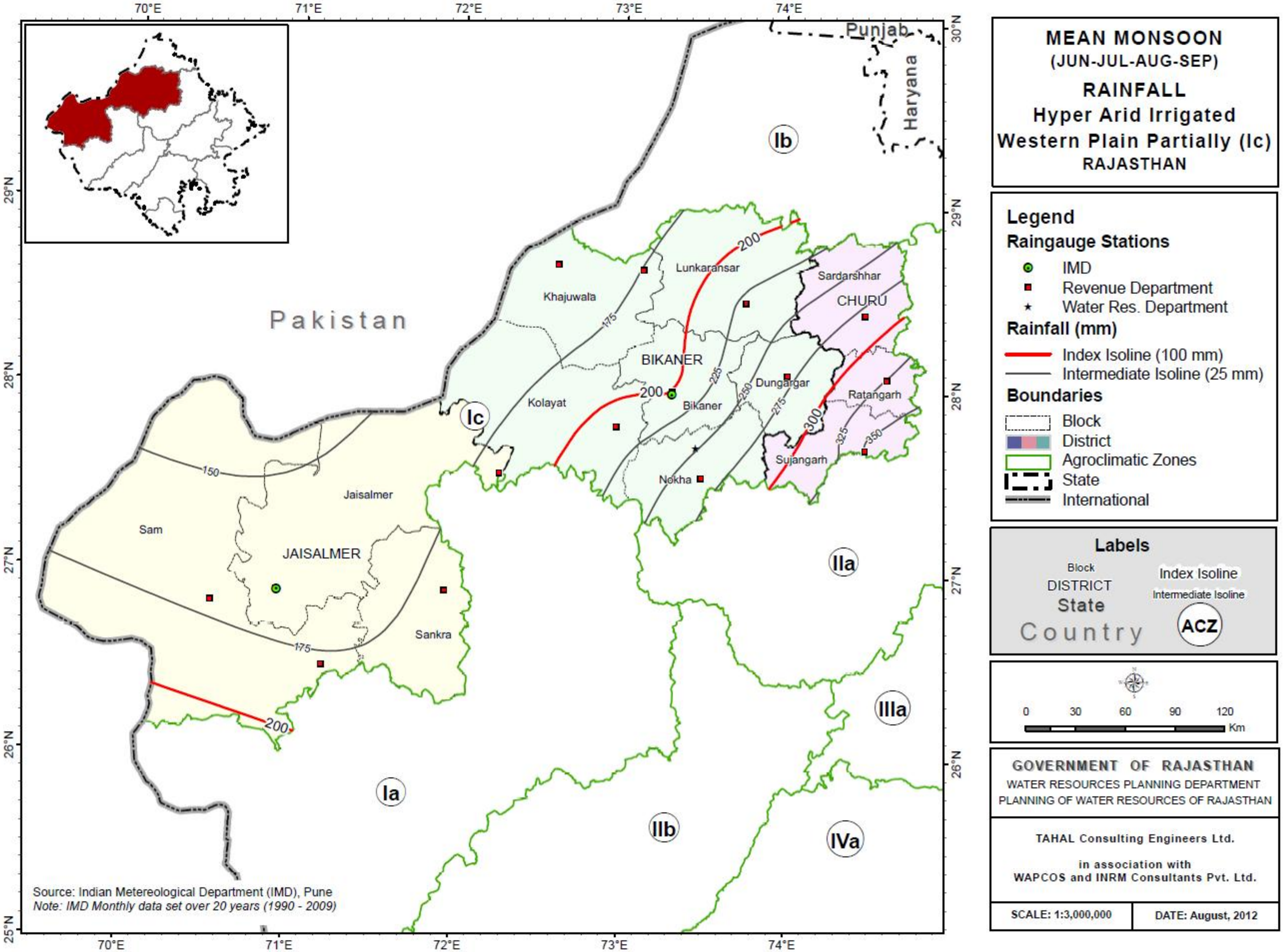
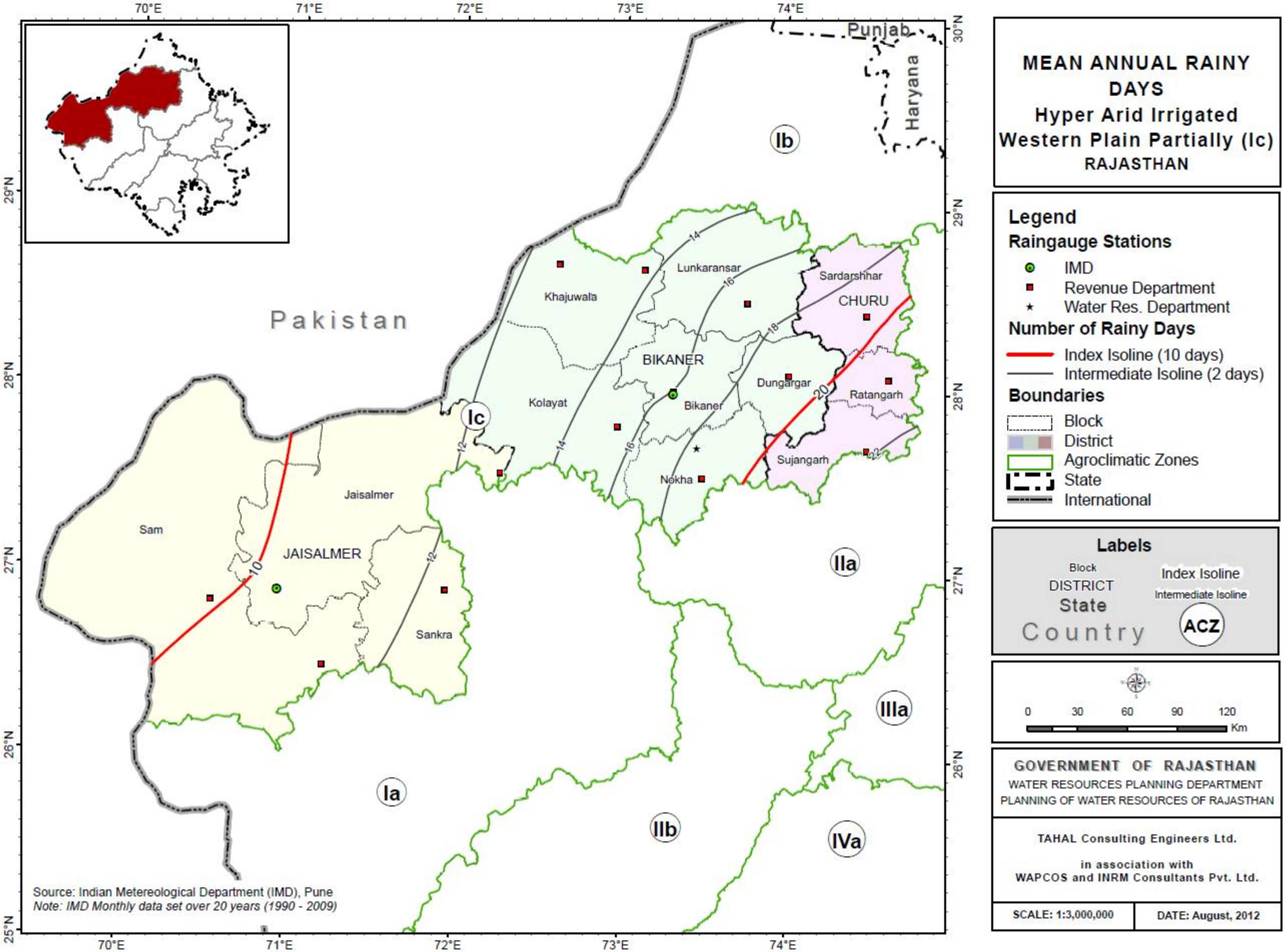
SCALE: 1:3,000,000
DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL RAINY DAYS
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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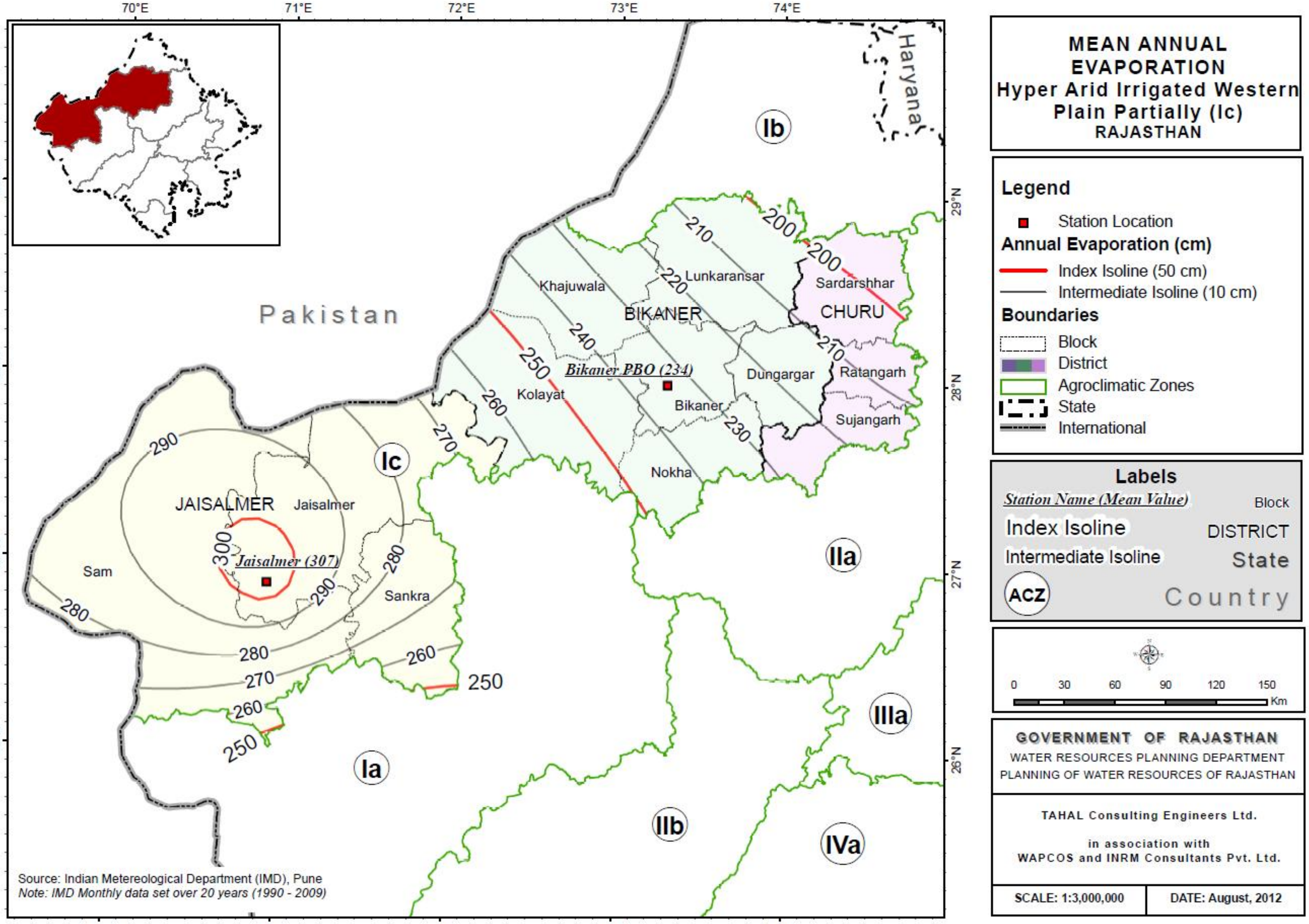
SCALE: 1:3,000,000
DATE: August, 2012



MEAN ANNUAL EVAPORATION
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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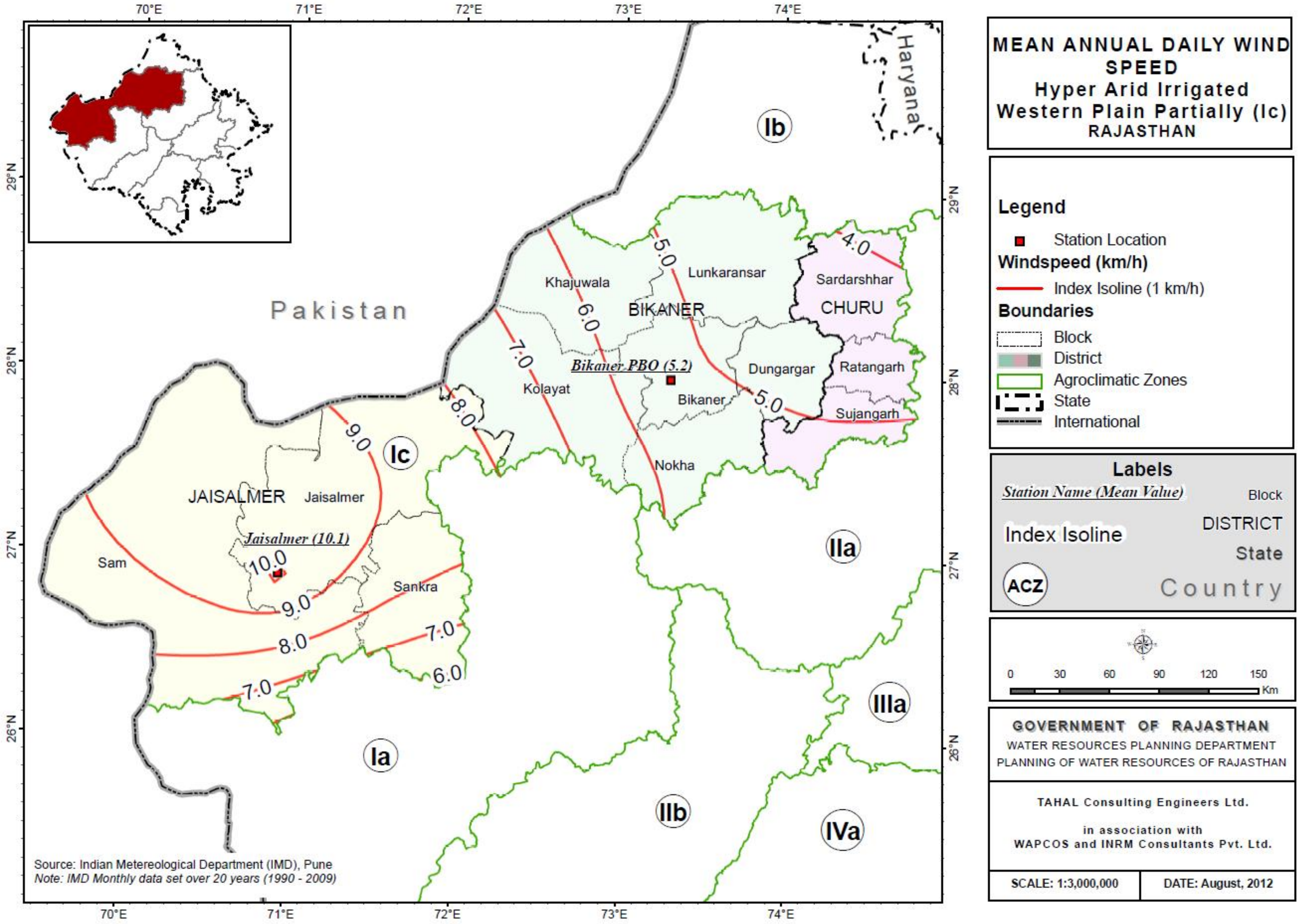
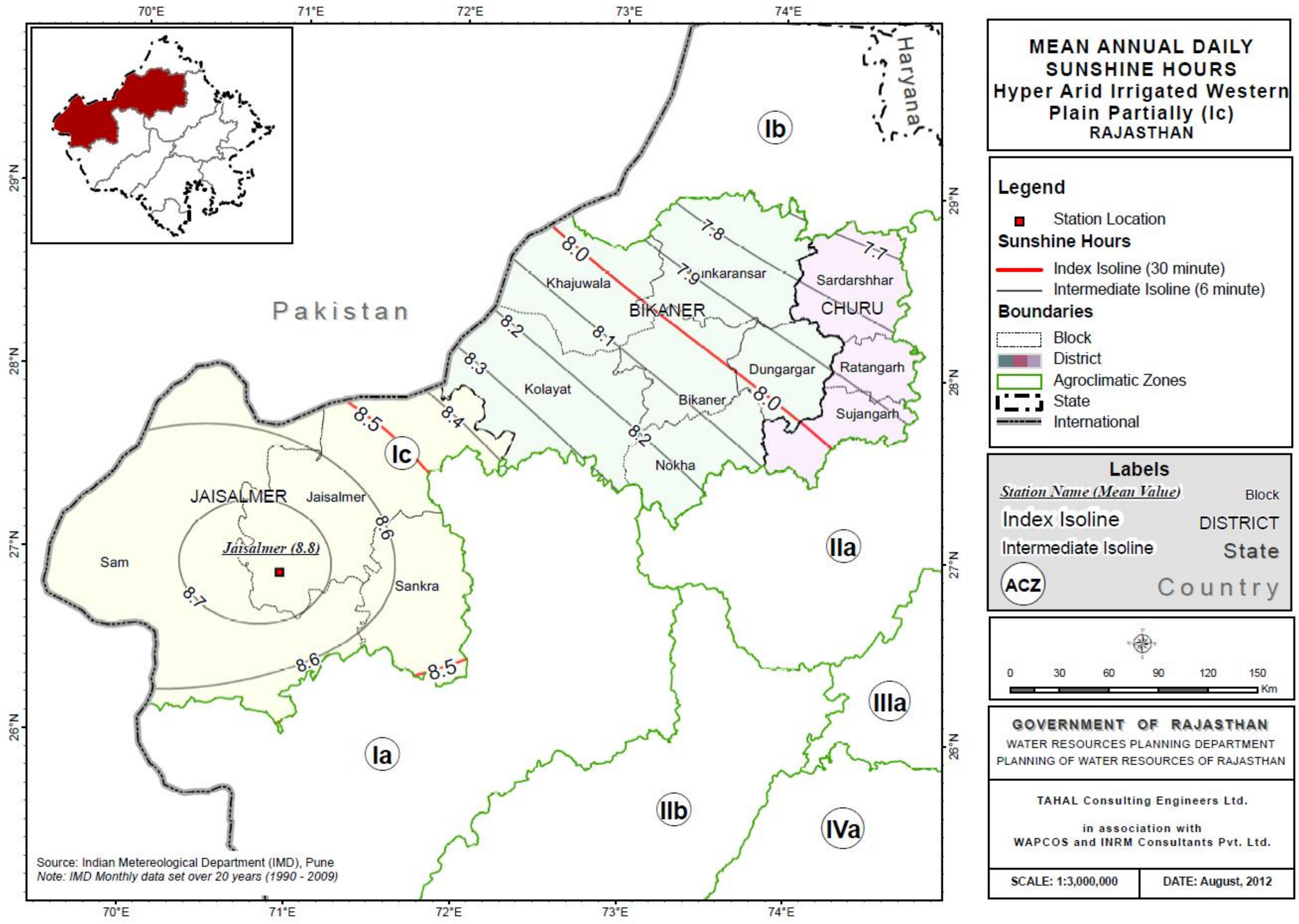
SCALE: 1:3,000,000	DATE: August, 2012



MEAN ANNUAL DAILY WIND SPEED
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL DAILY SUNSHINE HOURS
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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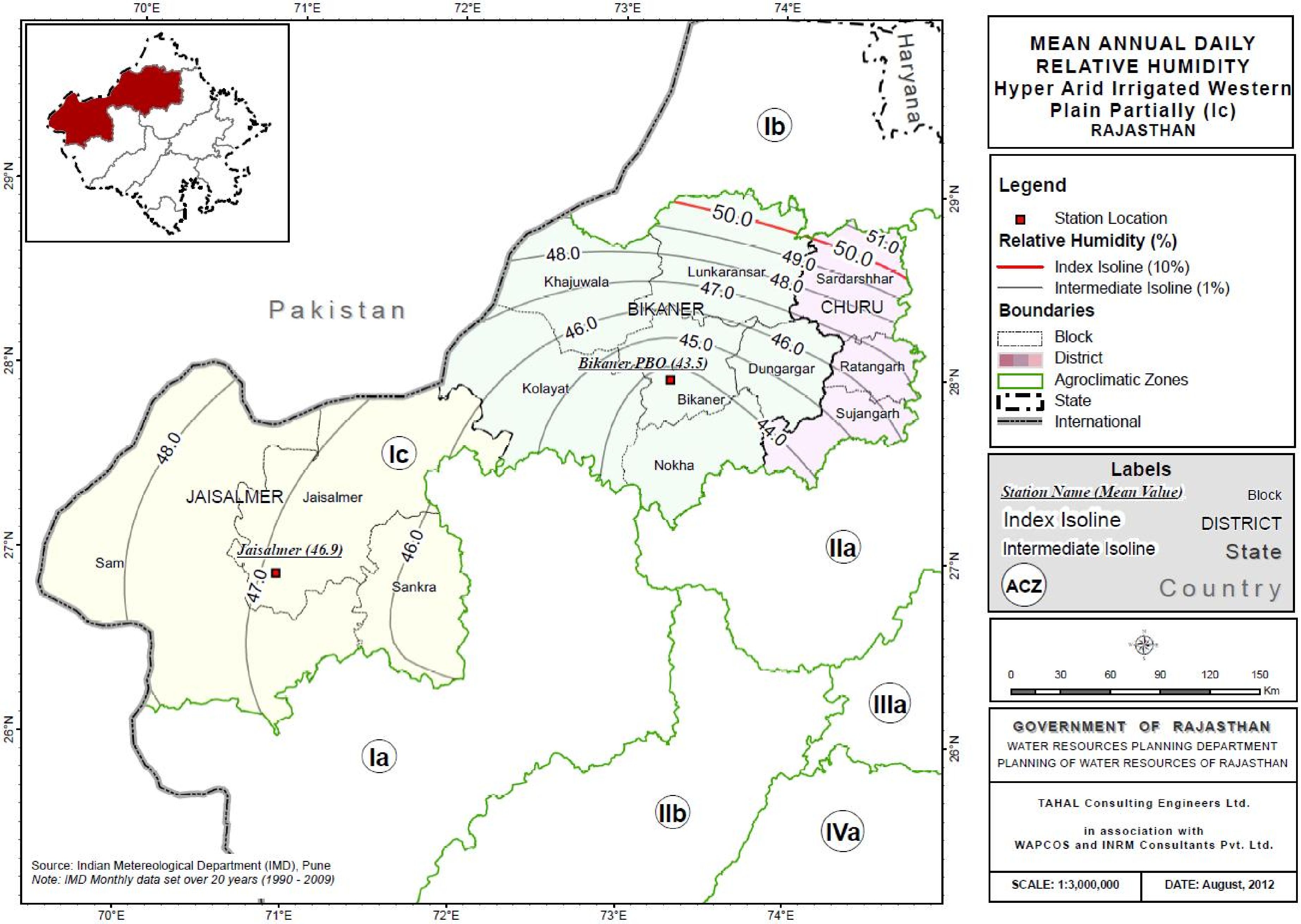
SCALE: 1:3,000,000
DATE: August, 2012



MEAN ANNUAL DAILY RELATIVE HUMIDITY
Hyper Arid Irrigated Western Plain Partially (Ic)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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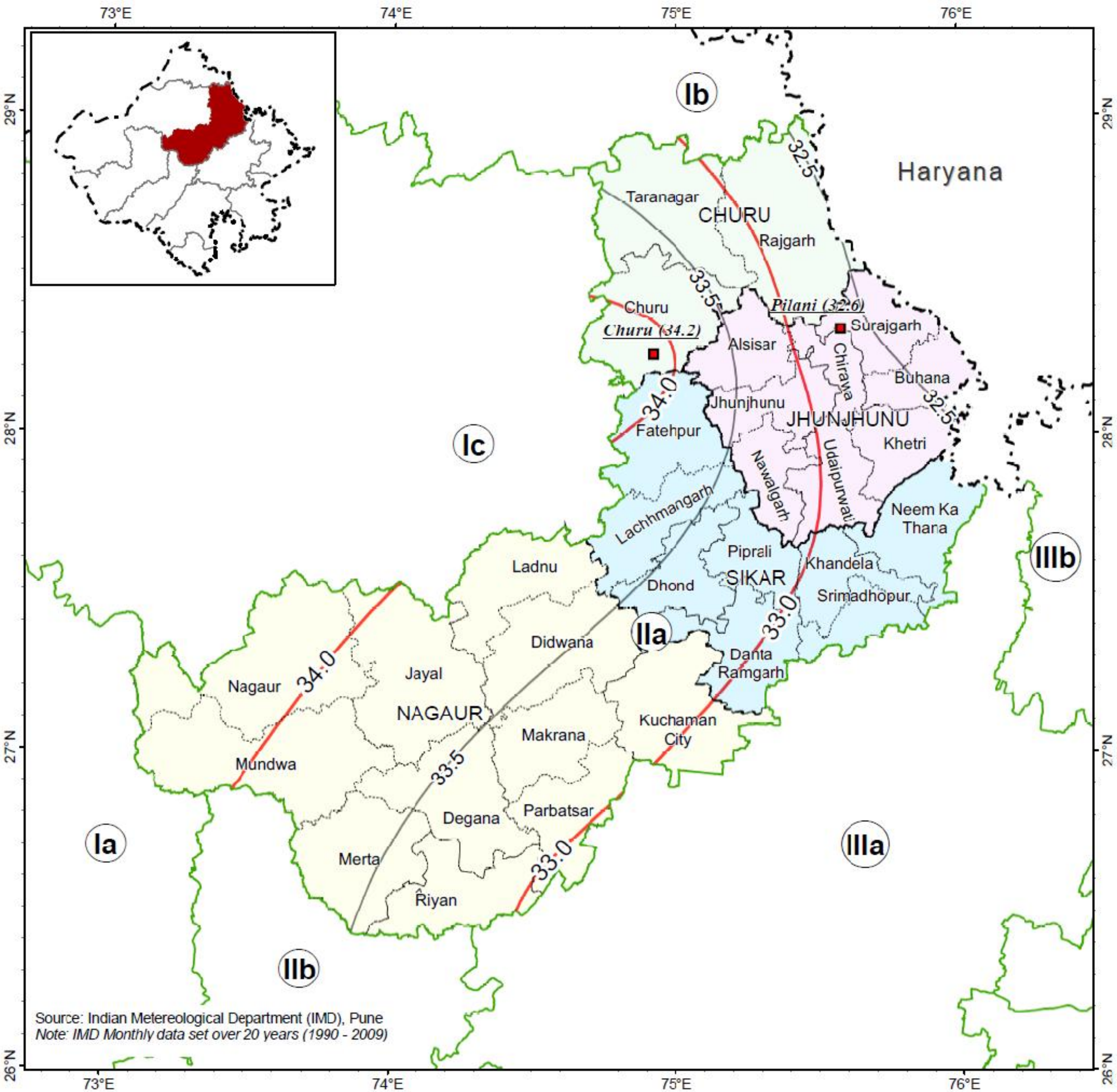
SCALE: 1:3,000,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

Legend

■ Station Location

Maximum Temperature (°C)

— Index Isoline (1.0°C)

— Intermediate Isoline (0.5°C)

Boundaries

⬚ Block

▬ District

▭ Agroclimatic Zones

▭ State

Labels

Station Name (Mean Value)	Block
Index Isoline	DISTRICT
Intermediate Isoline	State
ACZ	Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
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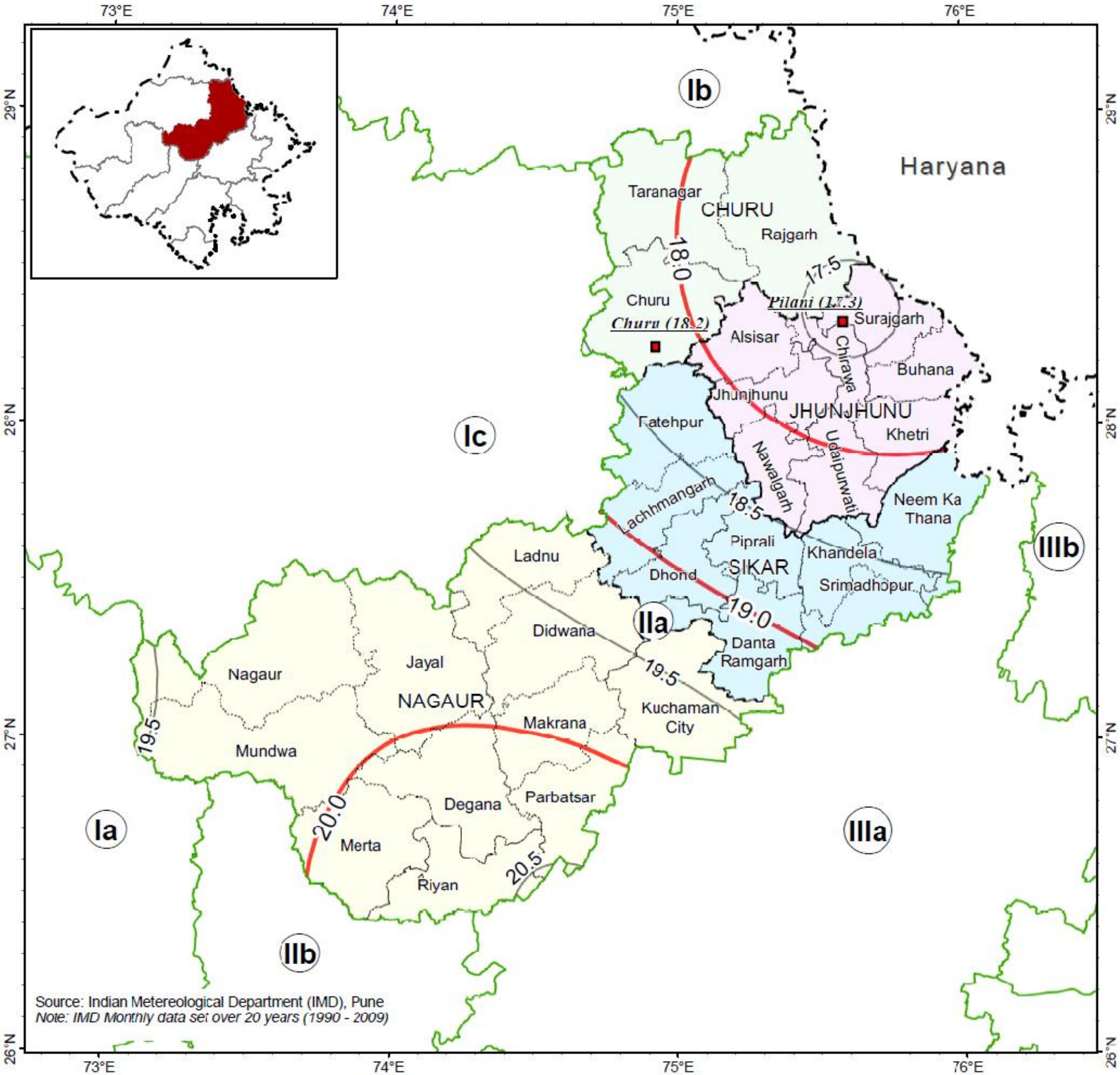
SCALE: 1:2,000,000	DATE: August, 2012

MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

■ Station Location

Minimum Temperature (°C)

- Index Isoline (1.0°C)
- Intermediate Isoline (0.5°C)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Station Name (Mean Value)	Block
Index Isoline	DISTRICT
Intermediate Isoline	State
ACZ	Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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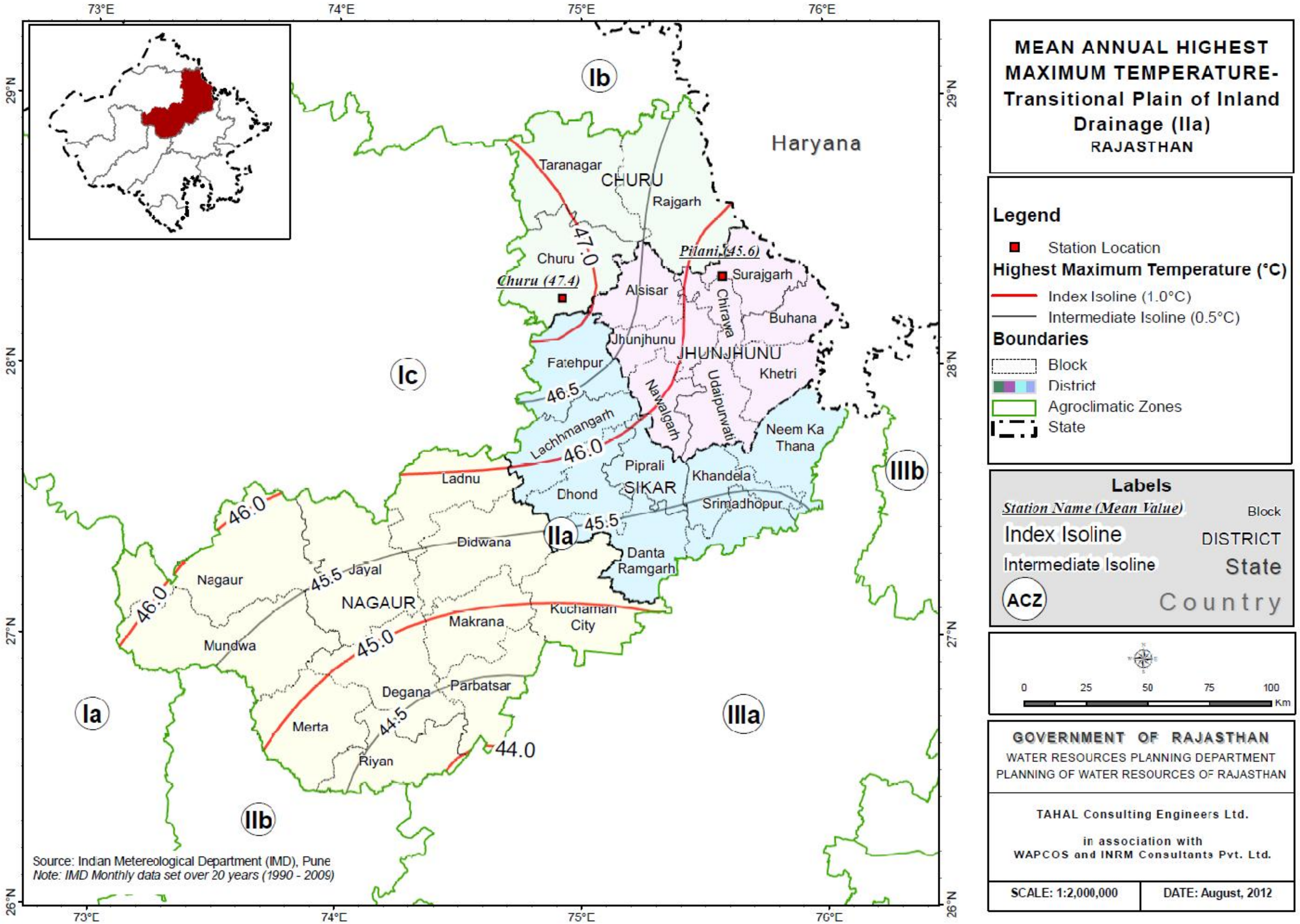
SCALE: 1:2,000,000	DATE: August, 2012



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE-
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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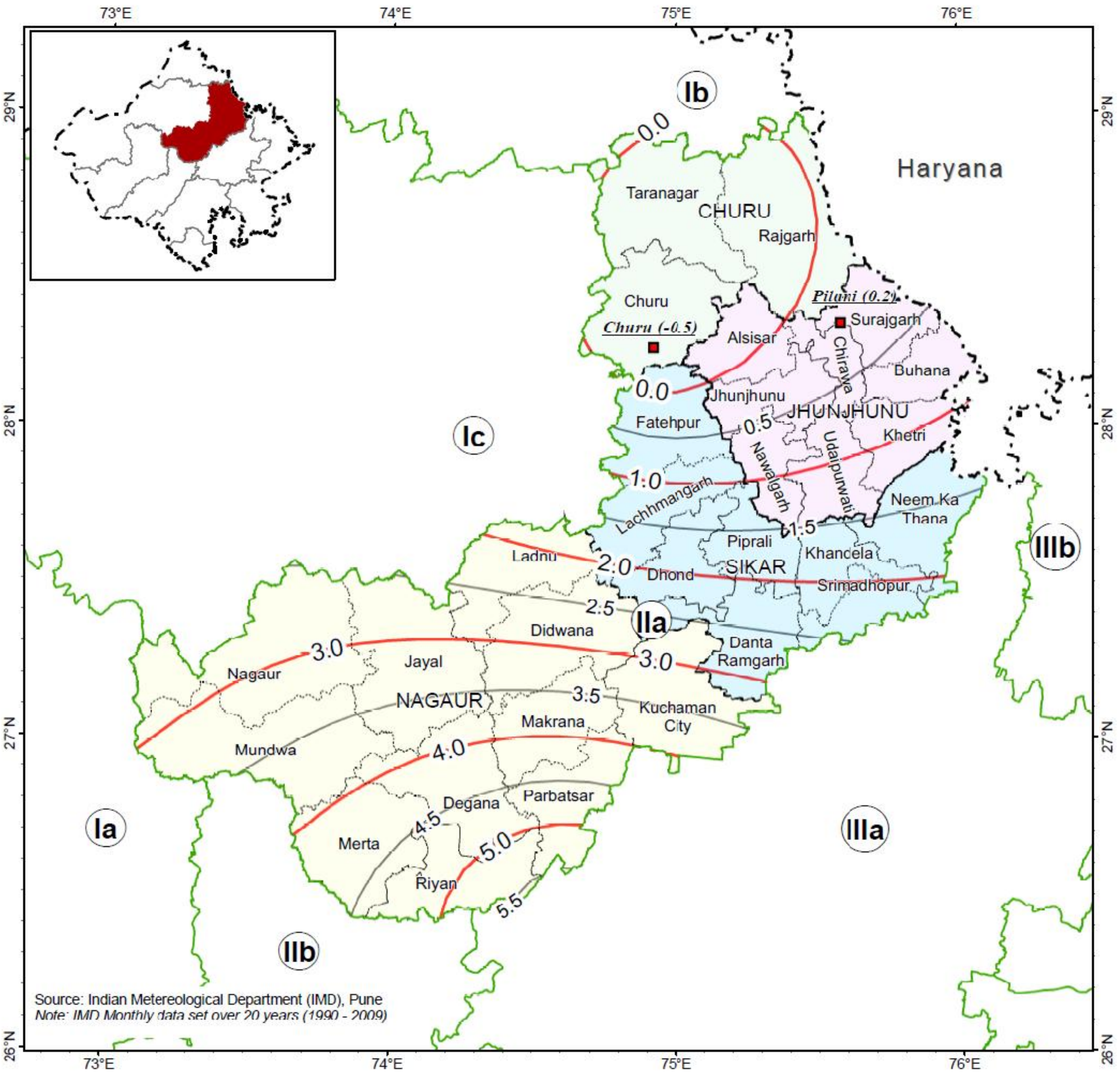
SCALE: 1:2,000,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL LOWEST MINIMUM TEMPERATURE- Transitional Plain of Inland Drainage (IIa)

RAJASTHAN

Legend

🟥 Station Location

Lowest Minimum Temperature (°C)

—	Index Isoline (1.0°C)
—	Intermediate Isoline (0.5°C)

Boundaries

▭	Block
▬	District
🟩	Agroclimatic Zones
▭	State

Labels

Station Name (Mean Value) Block
Index Isoline DISTRICT
Intermediate Isoline State
ACZ Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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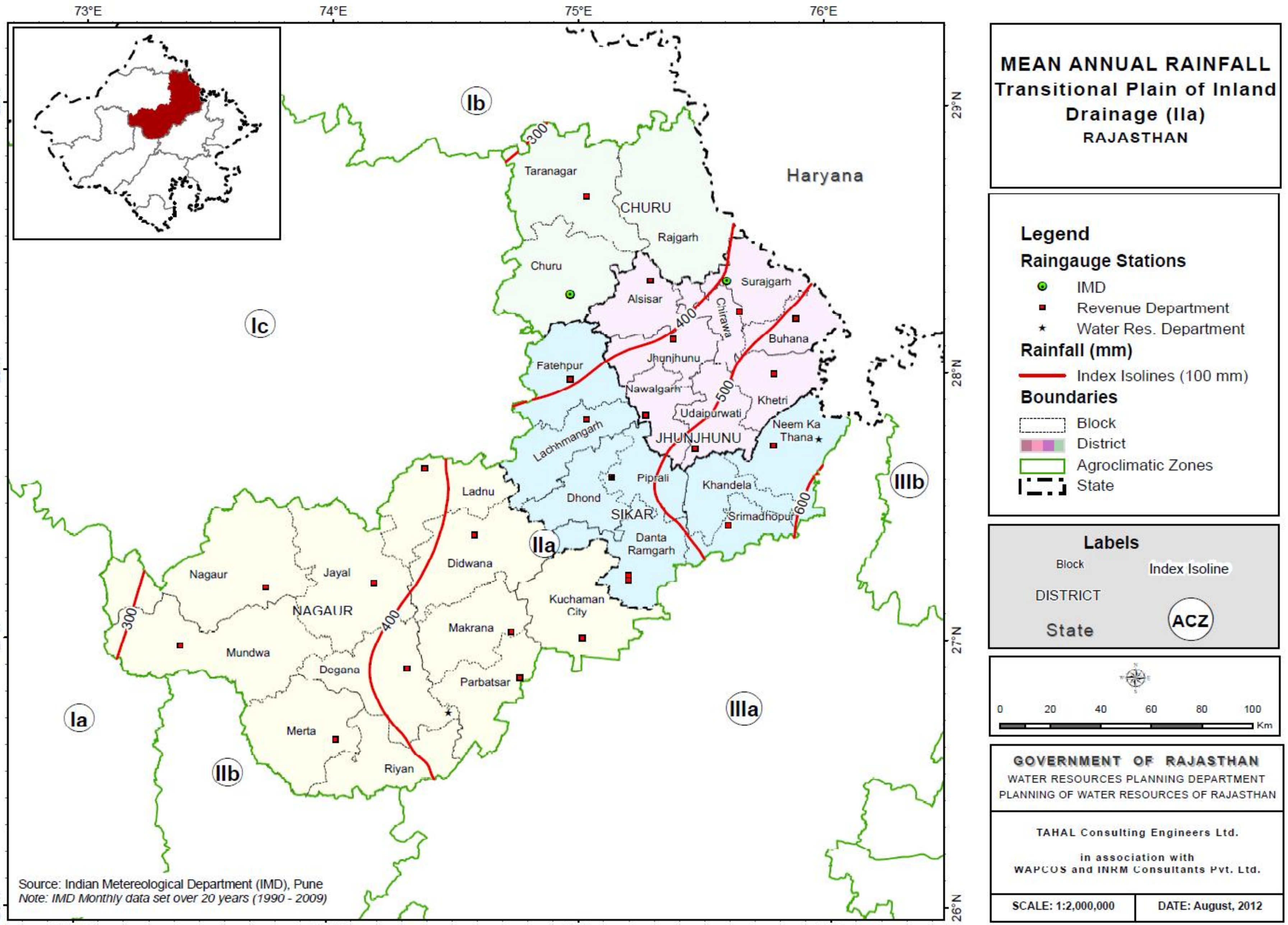
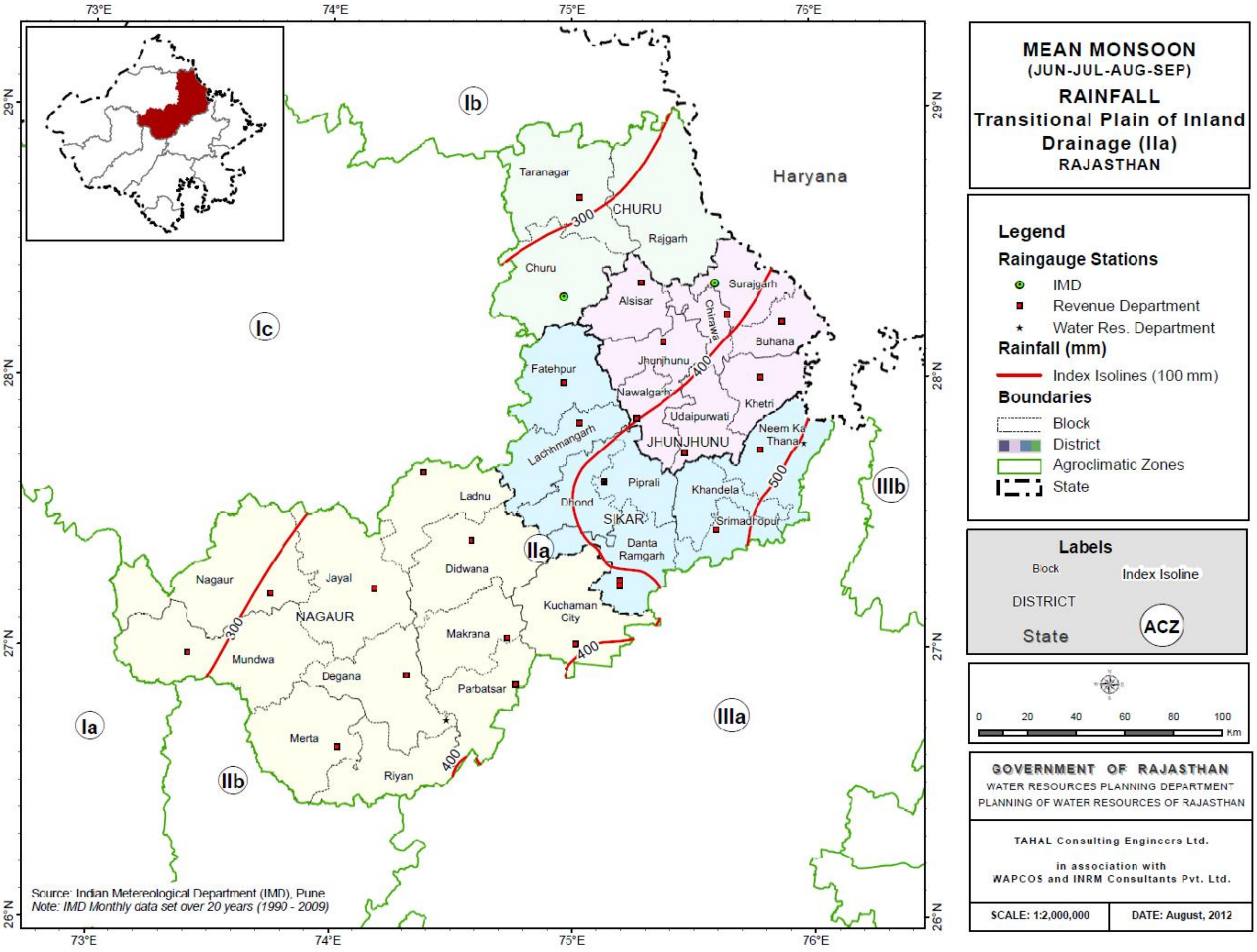
SCALE: 1:2,000,000	DATE: August, 2012


MEAN ANNUAL RAINFALL
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN
Legend
Raingauge Stations
IMD
Revenue Department
Water Res. Department
Rainfall (mm)
Index Isolines (100 mm)
Boundaries
Block
District
Agroclimatic Zones
State
Labels
Block
Index Isoline
DISTRICT
State
ACZ
0
20
40
60
80
100
Km
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN
TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.
SCALE: 1:2,000,000
DATE: August, 2012
73°E
74°E
75°E
76°E
29°N
28°N
27°N
26°N
Haryana
Ia
Ib
Ic
IIa
IIb
IIIa
IIIb
CHURU
Taranagar
Rajgarh
Churu
Alsisar
Chirawa
Surajgarh
Buhana
Fatehpur
Jhunjhunu
Nawalgarh
Udaipurwati
Khetri
Neem Ka Thana
JHUNJHUNU
Lachhmangarh
Piprali
Dhond
Khandela
SIKAR
Srimadhopur
Danta Ramgarh
Ladnu
Didwana
Nagaur
Jayal
NAGAUR
Kuchaman City
Makrana
Mundwa
Degana
Parbatsar
Merta
Riyan
300
400
500
600
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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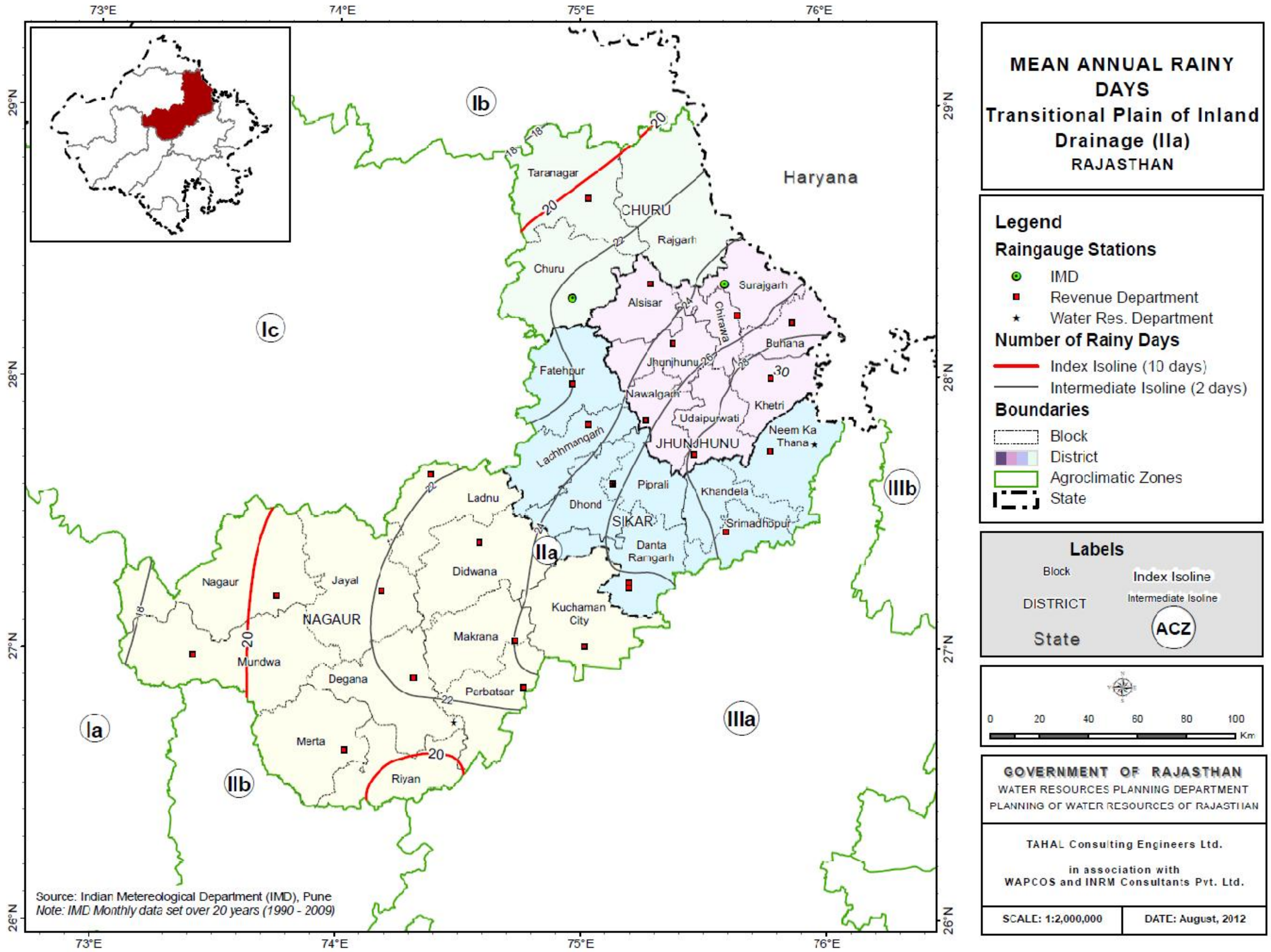
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL RAINY DAYS
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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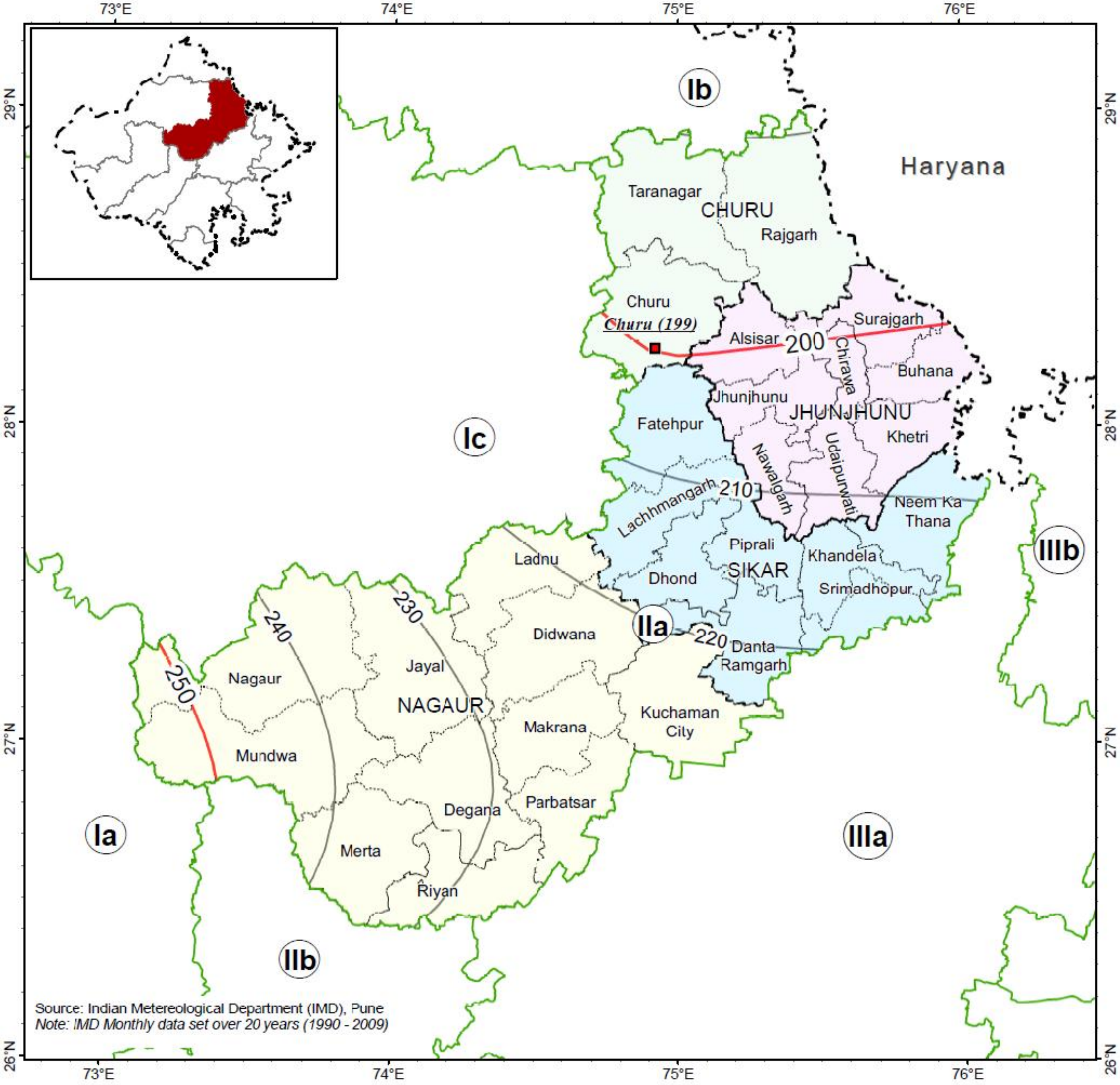
SCALE: 1:2,000,000 | DATE: August, 2012

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL EVAPORATION Transitional Plain of Inland Drainage (IIa)

RAJASTHAN

Legend

🟥 Station Location

Annual Evaporation (cm)

Index Isoline (50 cm)

Intermediate Isoline (10 cm)

Boundaries

Block

District

Agroclimatic Zones

State

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

Intermediate Isoline State

ACZ Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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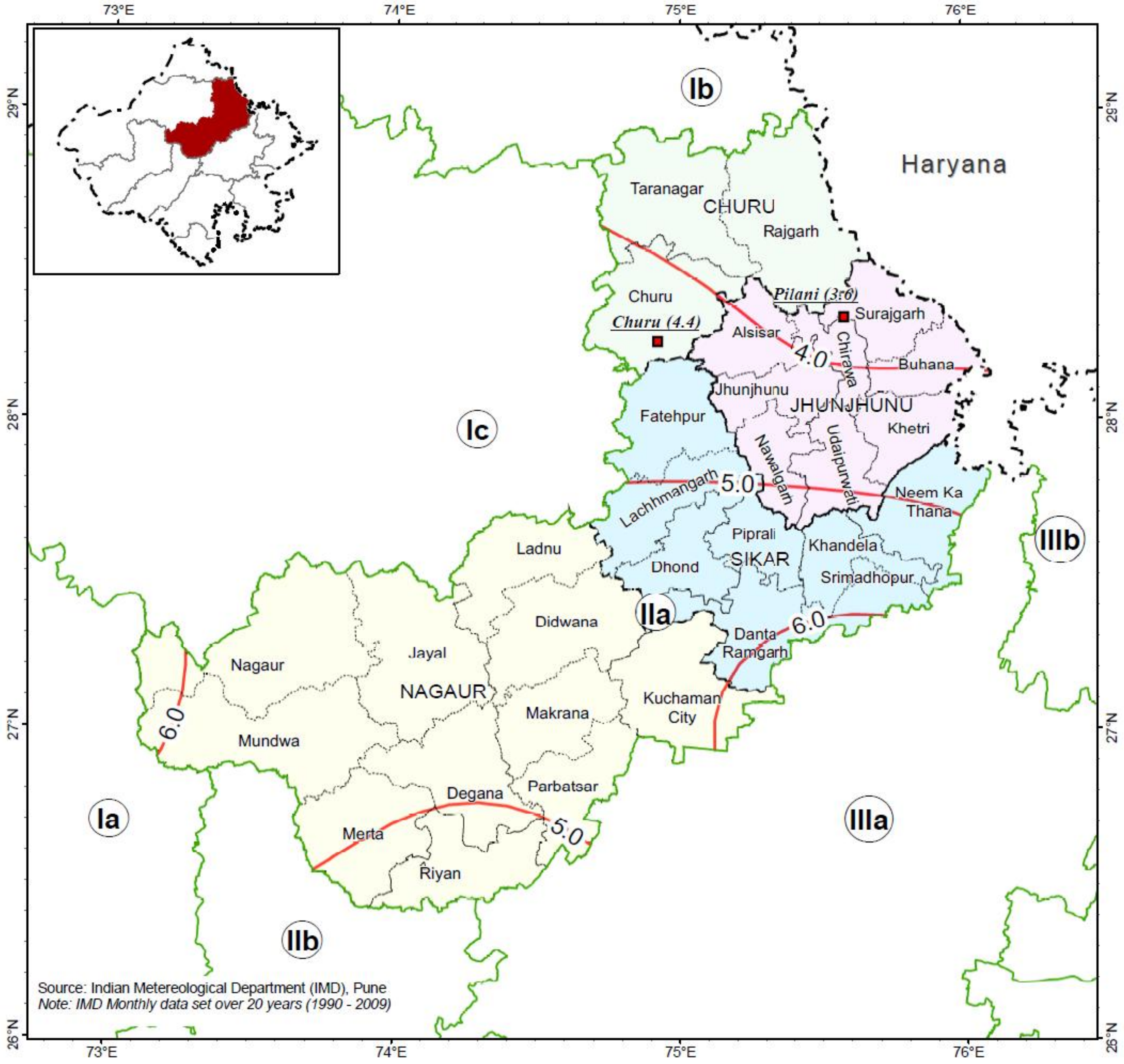
SCALE: 1:2,000,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

Legend

■ Station Location

Windspeed (km/h)

Index Isoline (1 km/h)

Boundaries

Block

District

Agroclimatic Zones

State

Labels

Station Name (Mean Value)

Block

DISTRICT

Index Isoline

State

ACZ

Country

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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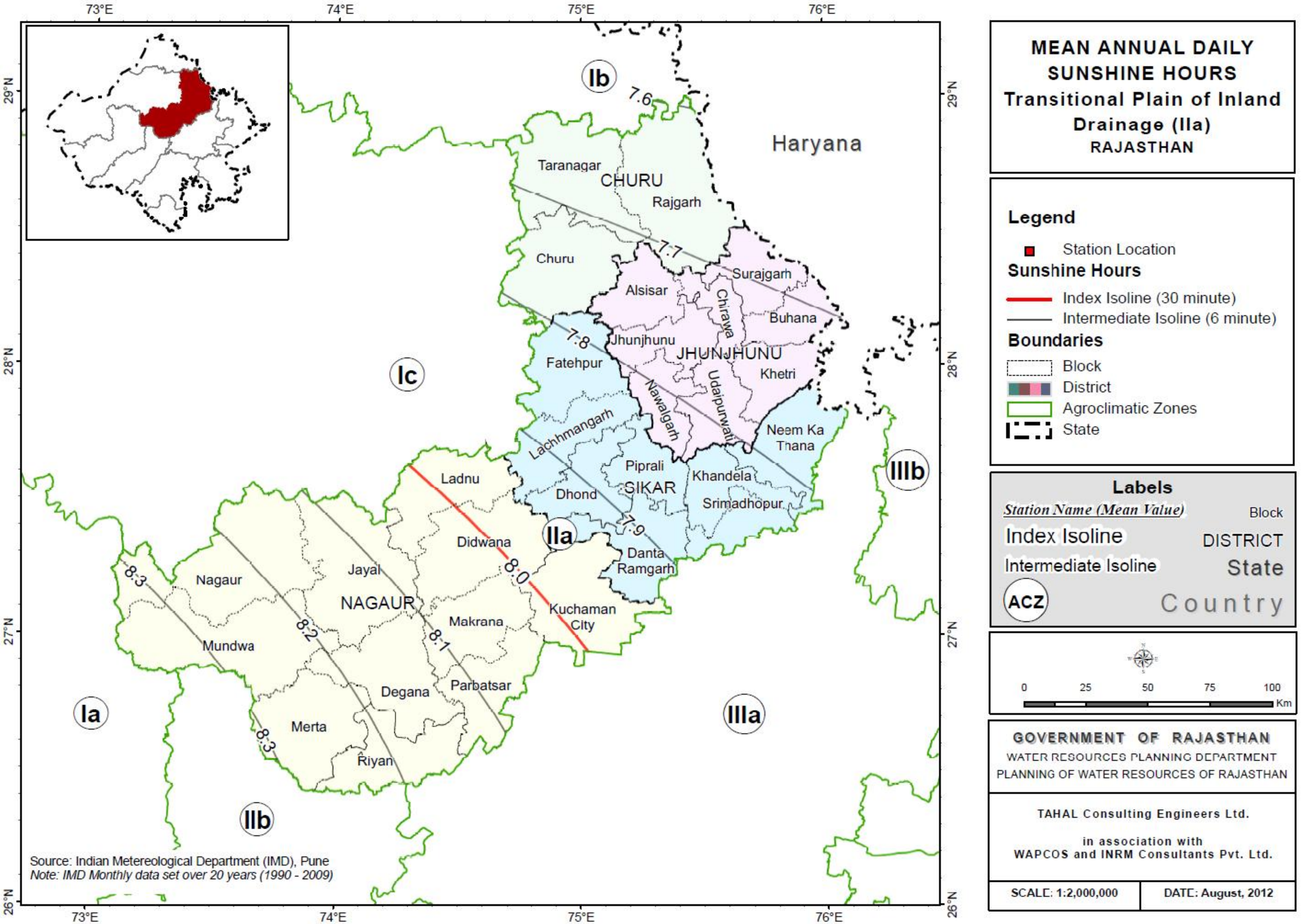
SCALE: 1:2,000,000	DATE: August, 2012



MEAN ANNUAL DAILY SUNSHINE HOURS
Transitional Plain of Inland Drainage (IIa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
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PLANNING OF WATER RESOURCES OF RAJASTHAN

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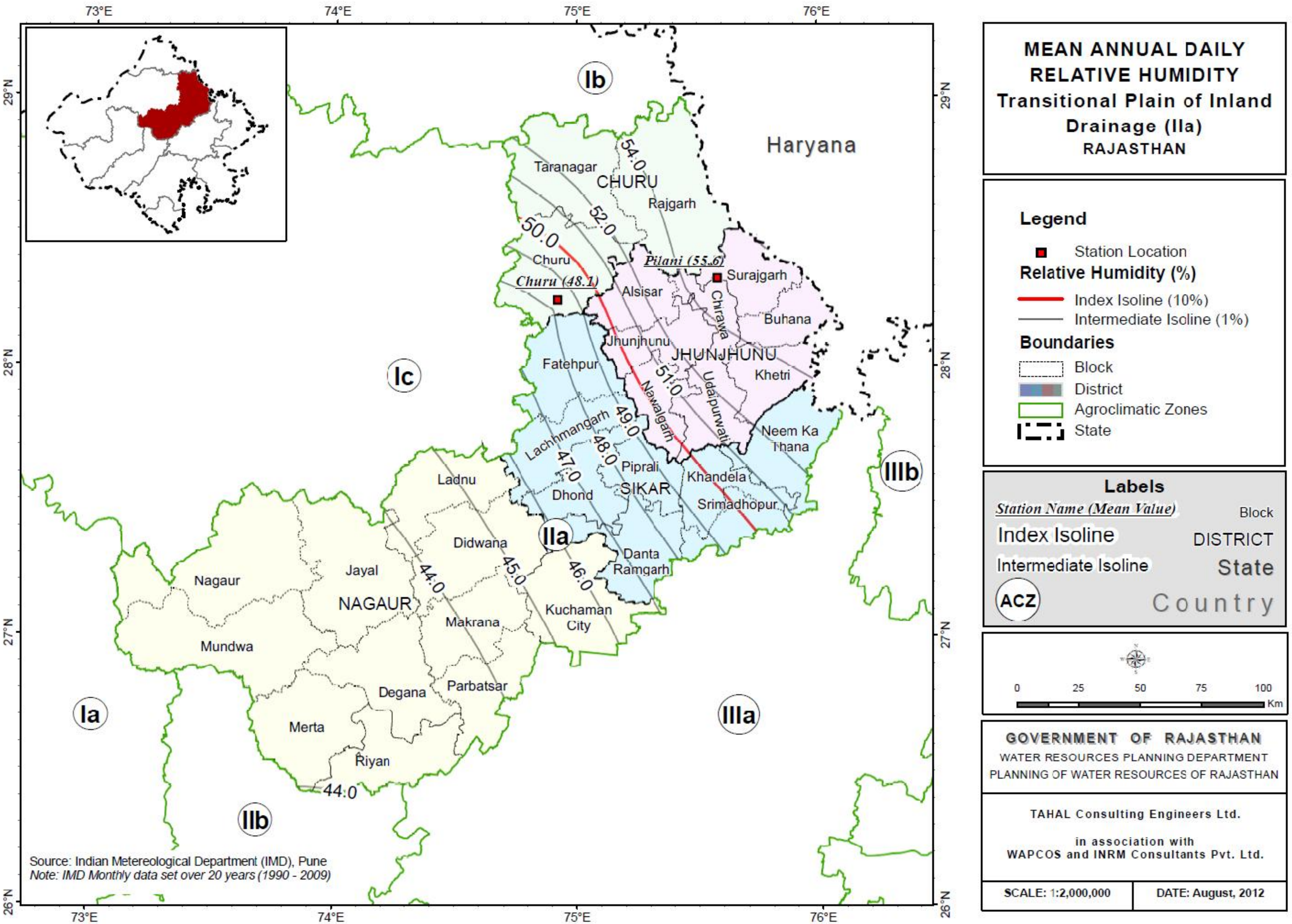
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL DAILY RELATIVE HUMIDITY

Transitional Plain of Inland Drainage (IIa)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN

WATER RESOURCES PLANNING DEPARTMENT

PLANNING OF WATER RESOURCES OF RAJASTHAN

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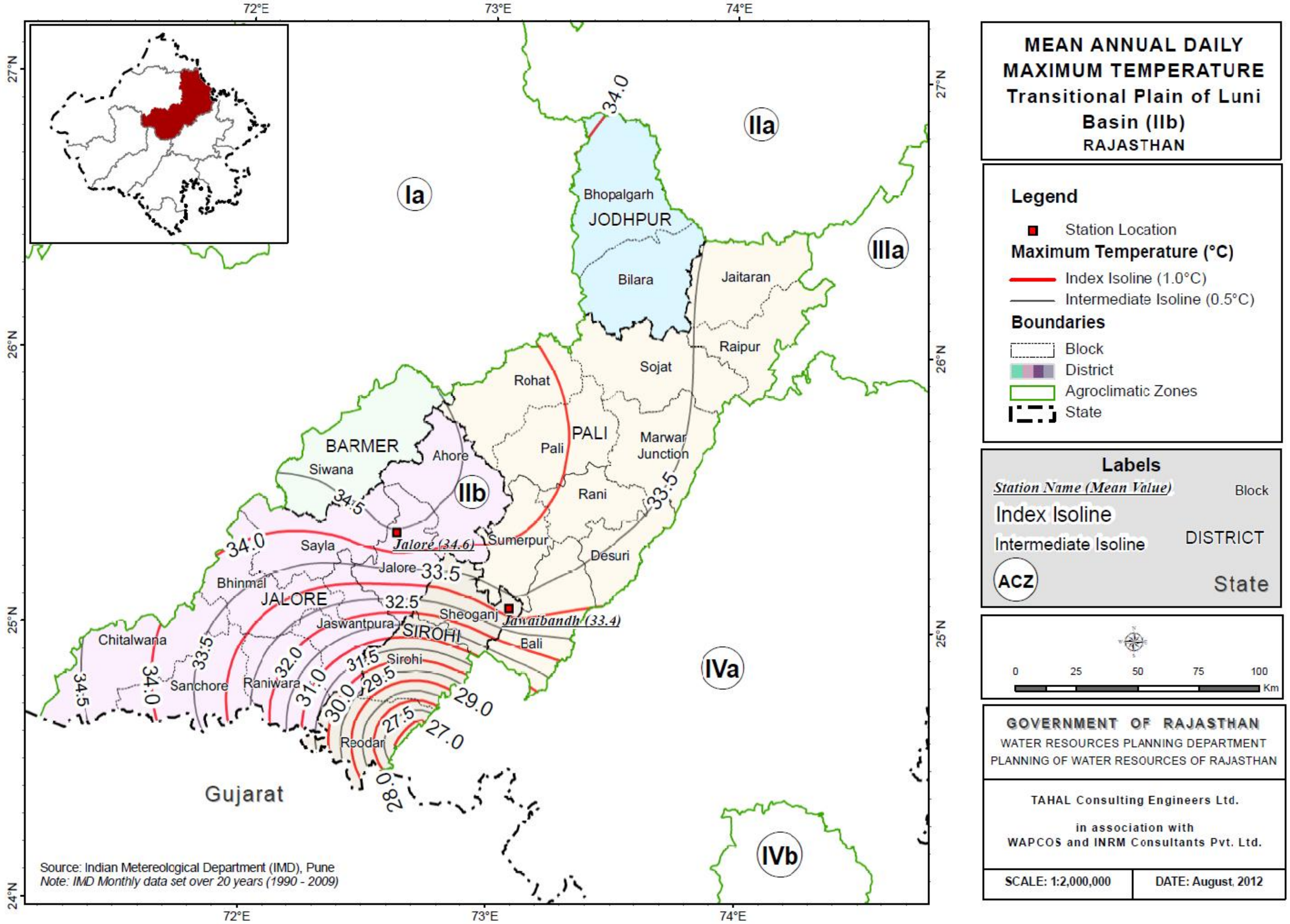
SCALE: 1:2,000,000	DATE: August, 2012

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Transitional Plain of Luni Basin (IIb)
RAJASTHAN



Source: Indian Metereolcgical Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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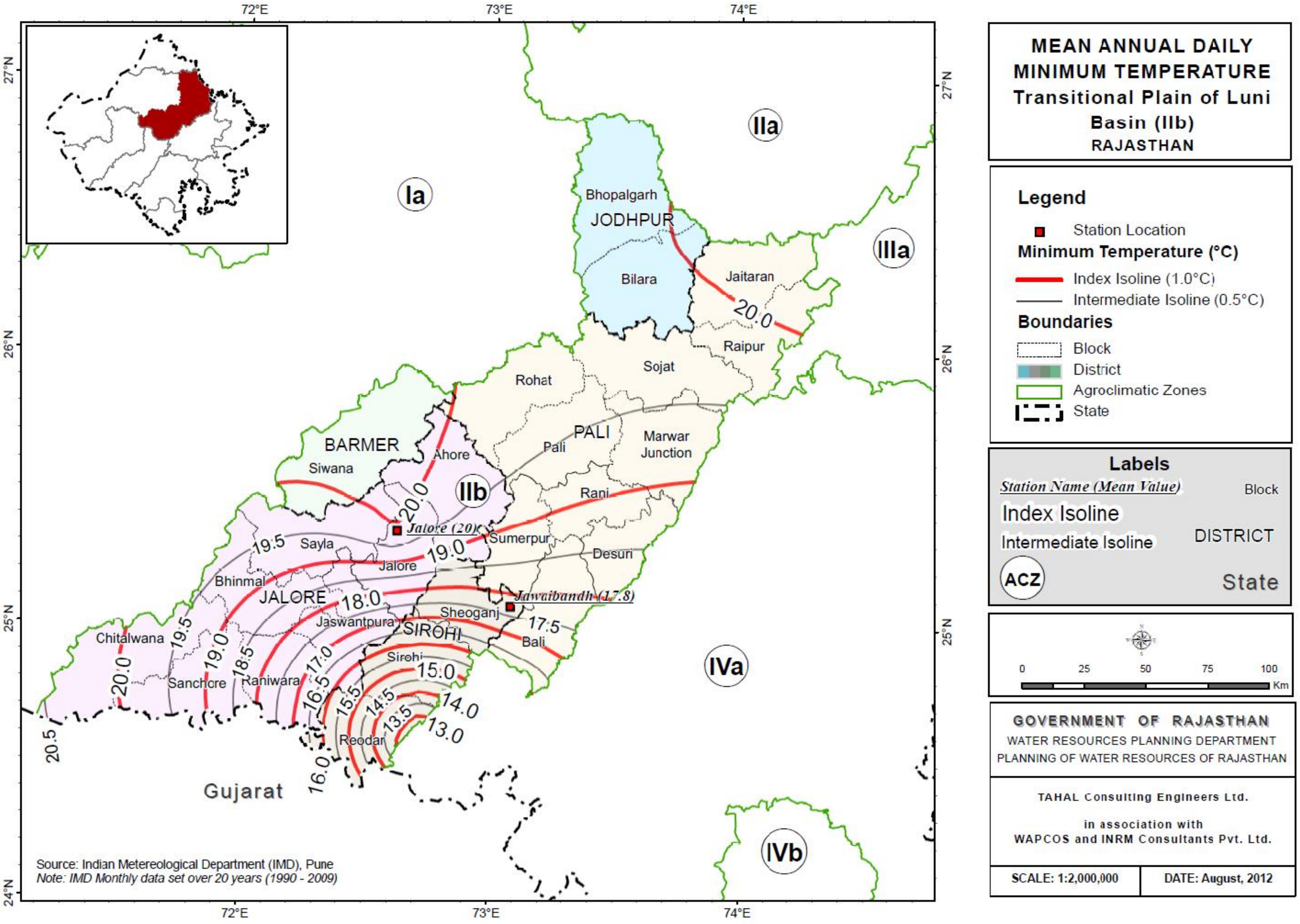
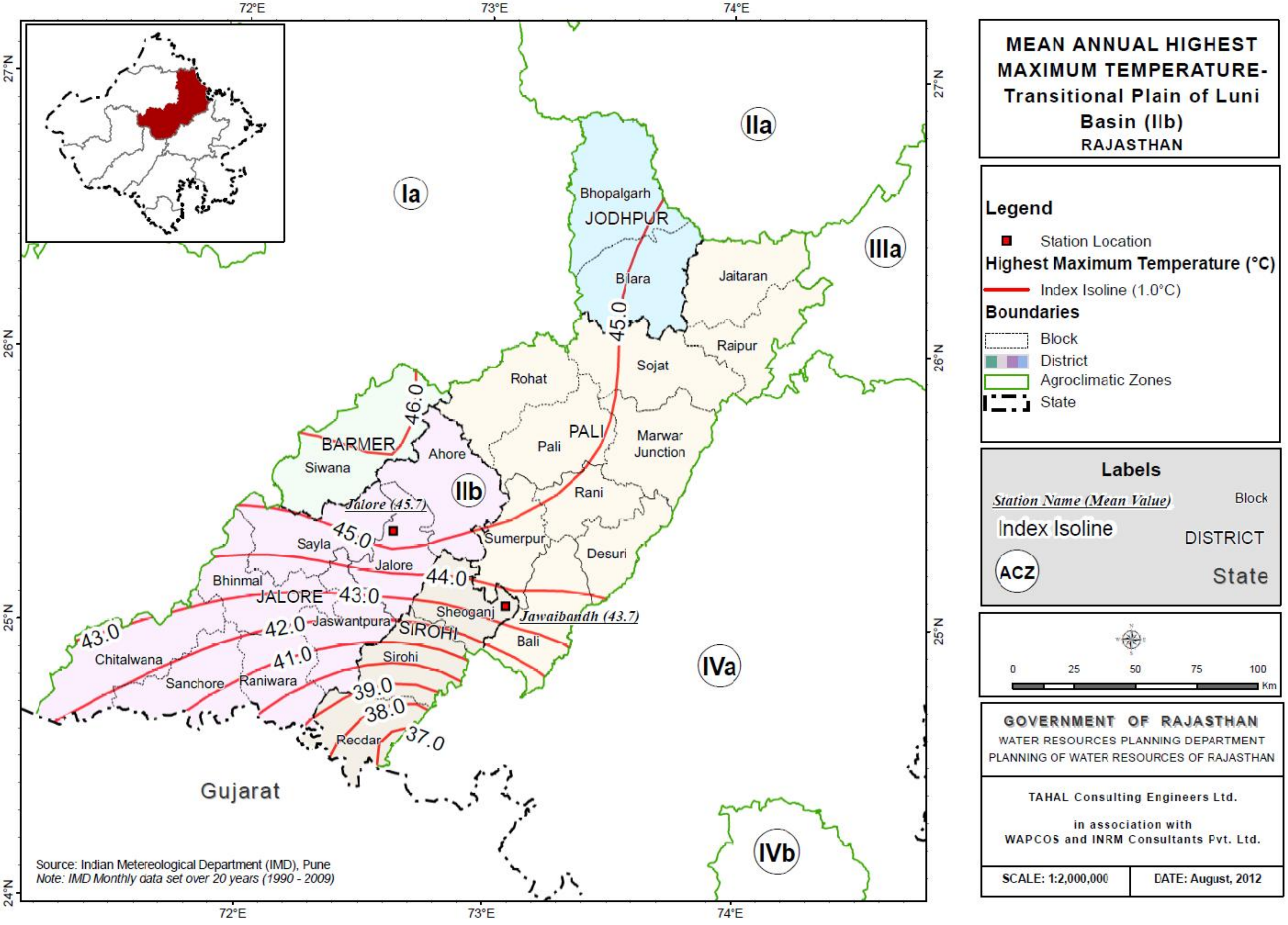
SCALE: 1:2,000,000

DATE: August, 2012



MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Transitional Plain of Luni Basin (IIb)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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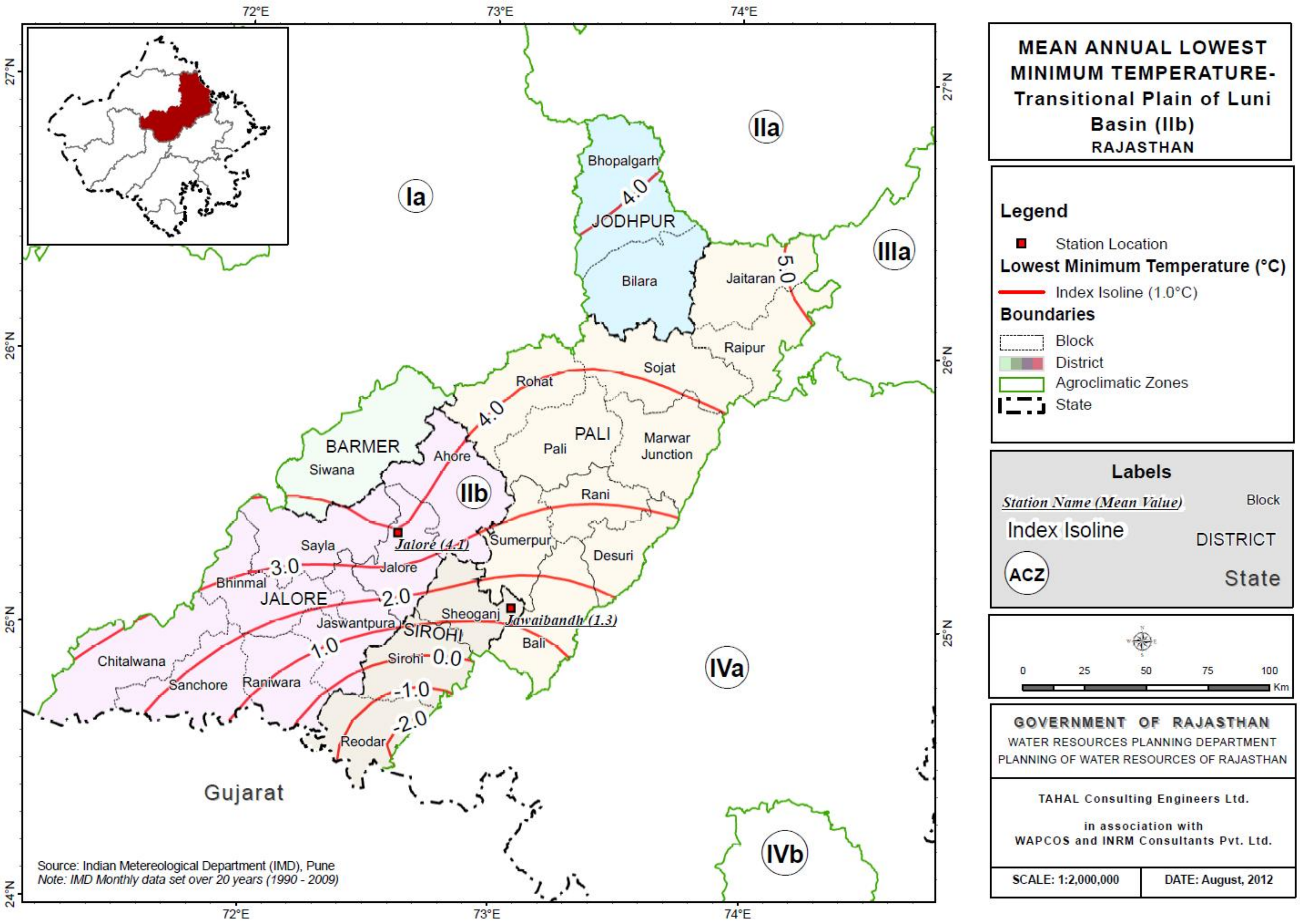
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL LOWEST MINIMUM TEMPERATURE- Transitional Plain of Luni Basin (IIb)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
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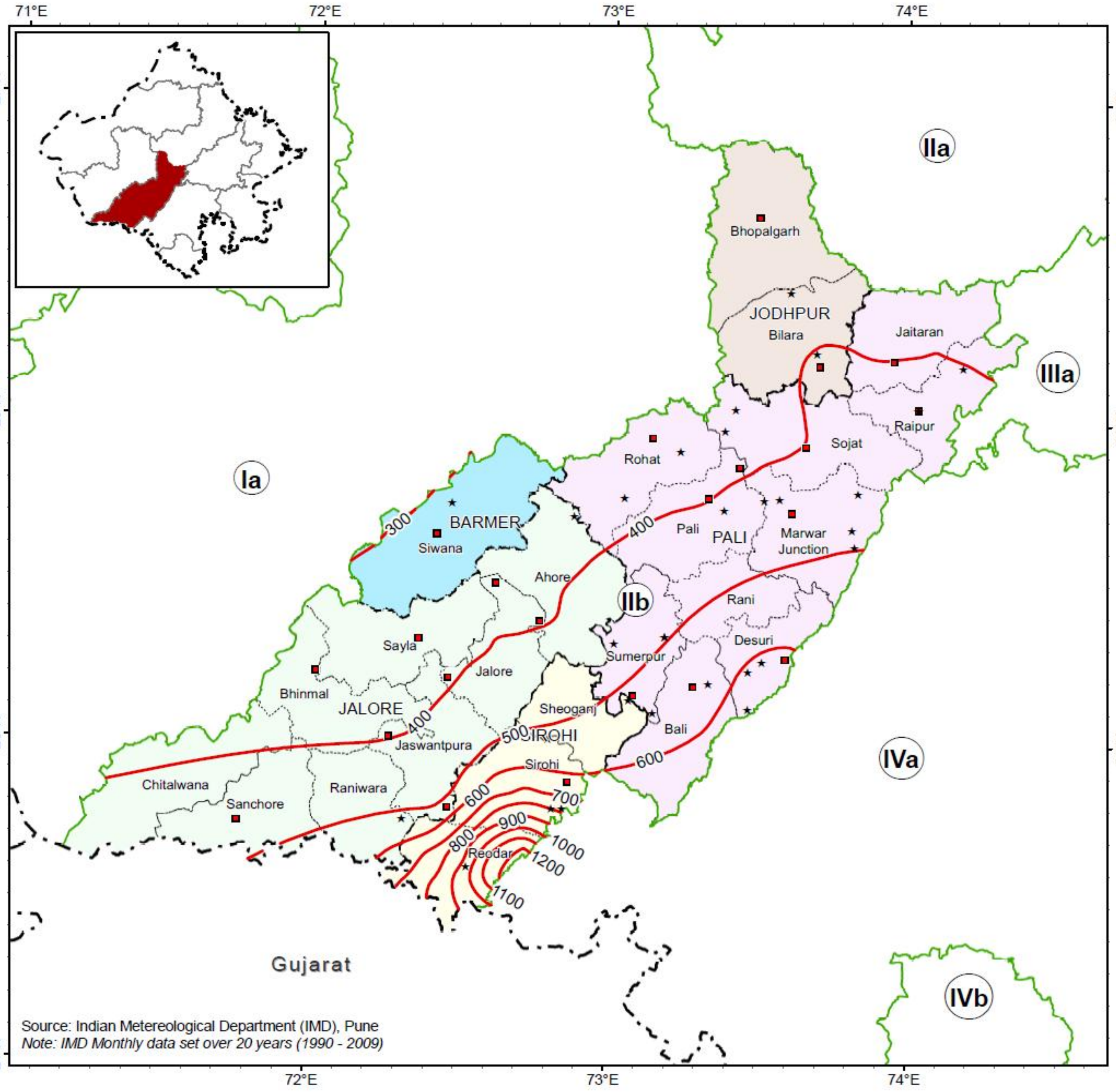
SCALE: 1:2,000,000

DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL RAINFALL
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)

- ― Index Isolines (100 mm)

Boundaries

- ▭ Block
- ▨ District
- 🟩 Agroclimatic Zones
- ▭ State

Labels

Block
Index Isoline
DISTRICT
State
ACZ

0 20 40 60 80 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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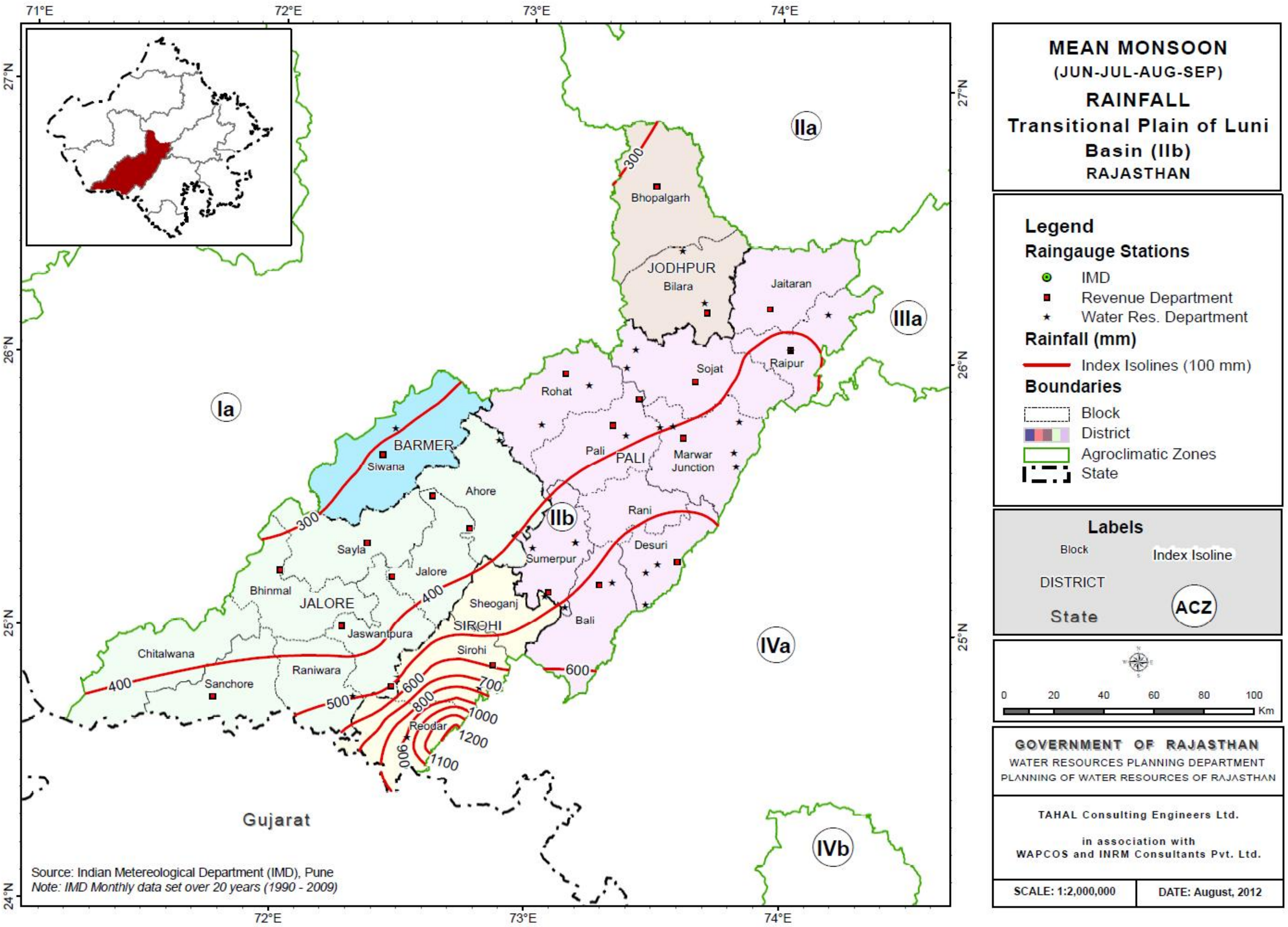
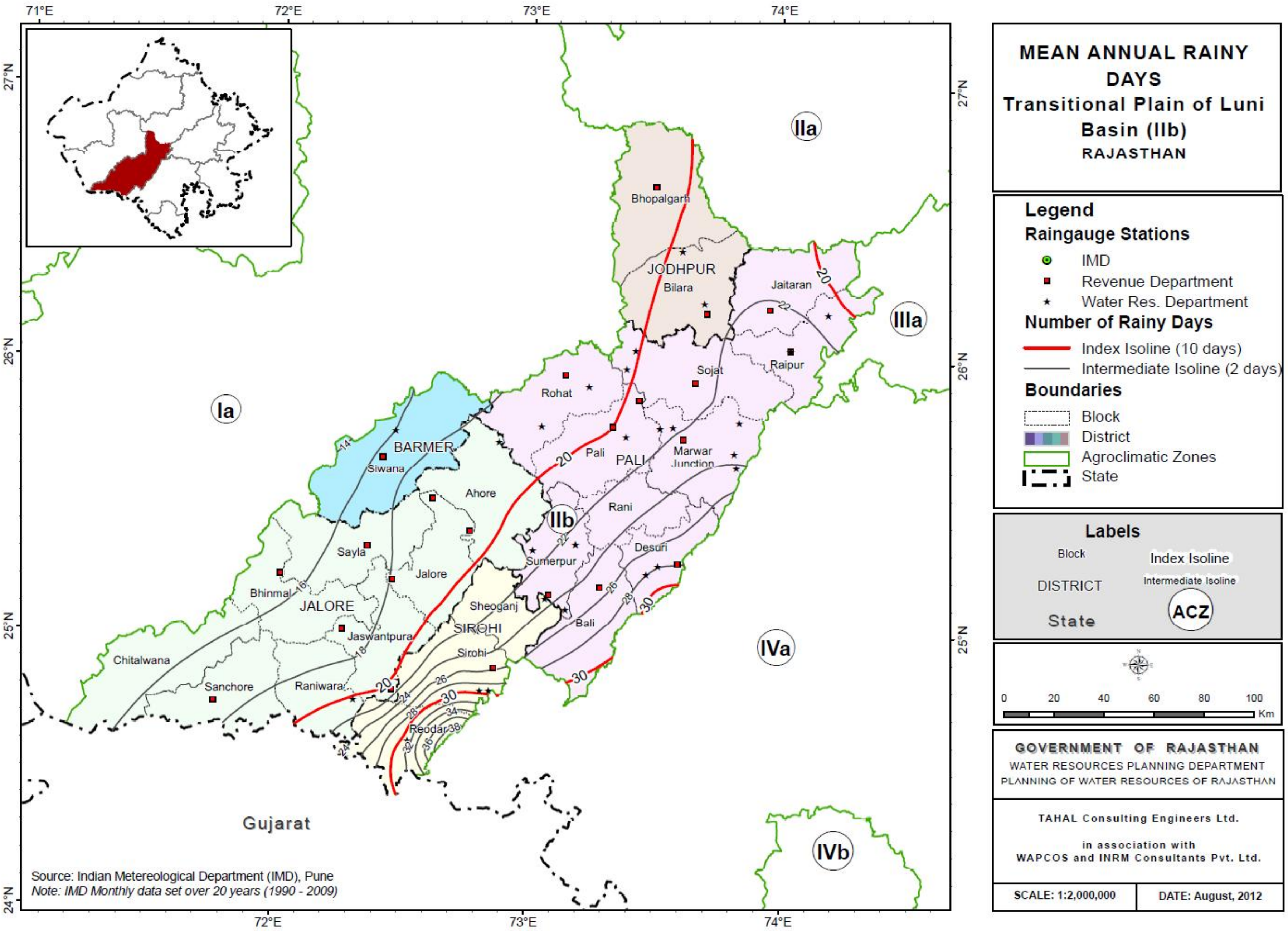
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000	DATE: August, 2012


MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Transitional Plain of Luni Basin (IIb)
RAJASTHAN
Legend
Raingauge Stations
IMD
Revenue Department
Water Res. Department
Rainfall (mm)
Index Isolines (100 mm)
Boundaries
Block
District
Agroclimatic Zones
State
Labels
Block
Index Isoline
DISTRICT
State
ACZ
0
20
40
60
80
100
Km
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN
TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.
SCALE: 1:2,000,000
DATE: August, 2012
71°E
72°E
73°E
74°E
27°N
26°N
25°N
24°N
IIa
IIIa
Ia
IIb
IVa
IVb
Gujarat
JODHPUR
Bhopalgarh
Bilara
Jaitaran
Raipur
Sojat
Rohat
Pali
PALI
Marwar Junction
Rani
Desuri
Bali
Sumerpur
BARMER
Siwana
Ahore
Sayla
Jalore
Bhinmal
JALORE
Jaswantpura
Sheoganj
SIROHI
Sirohi
Chitalwana
Raniwara
Sanchore
Reodar
300
400
500
600
700
800
900
1000
1100
1200
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL RAINY DAYS
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Number of Rainy Days

- Index Isoline (10 days)
- Intermediate Isoline (2 days)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Block
Index Isoline
DISTRICT
Intermediate Isoline
State
ACZ

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
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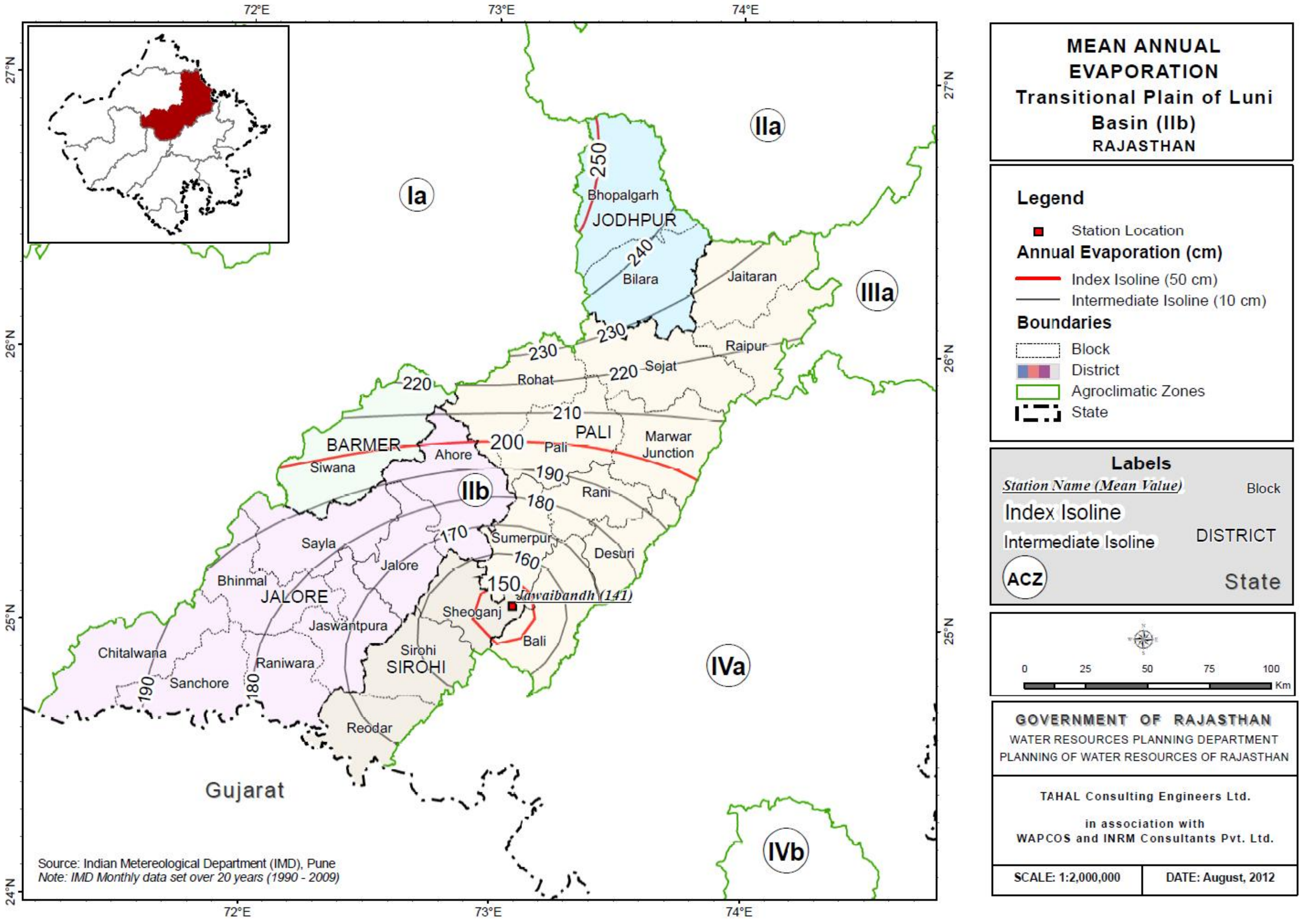
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL EVAPORATION
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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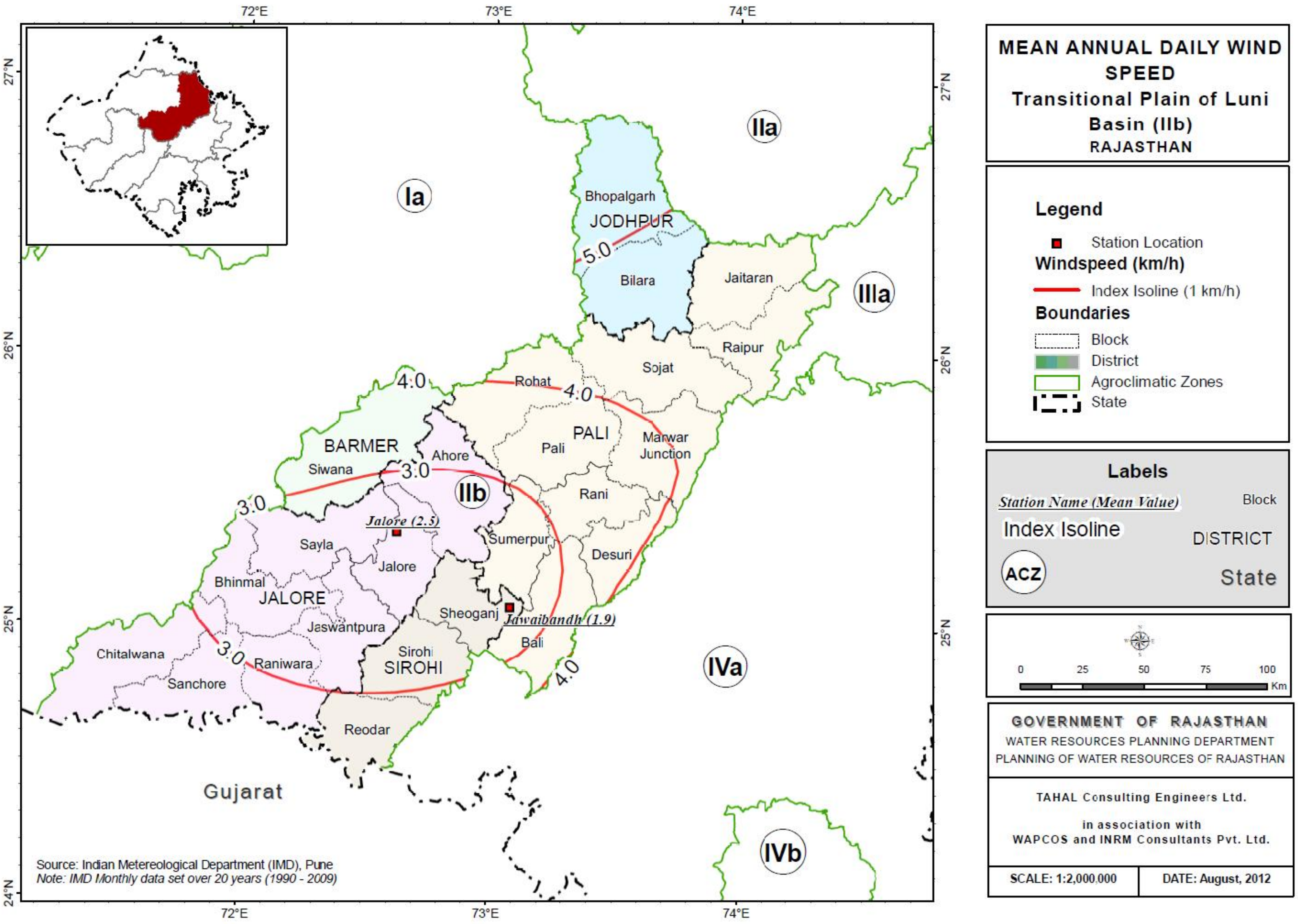
SCALE: 1:2,000,000	DATE: August, 2012

MEAN ANNUAL DAILY WIND SPEED
Transitional Plain of Luni Basin (IIb)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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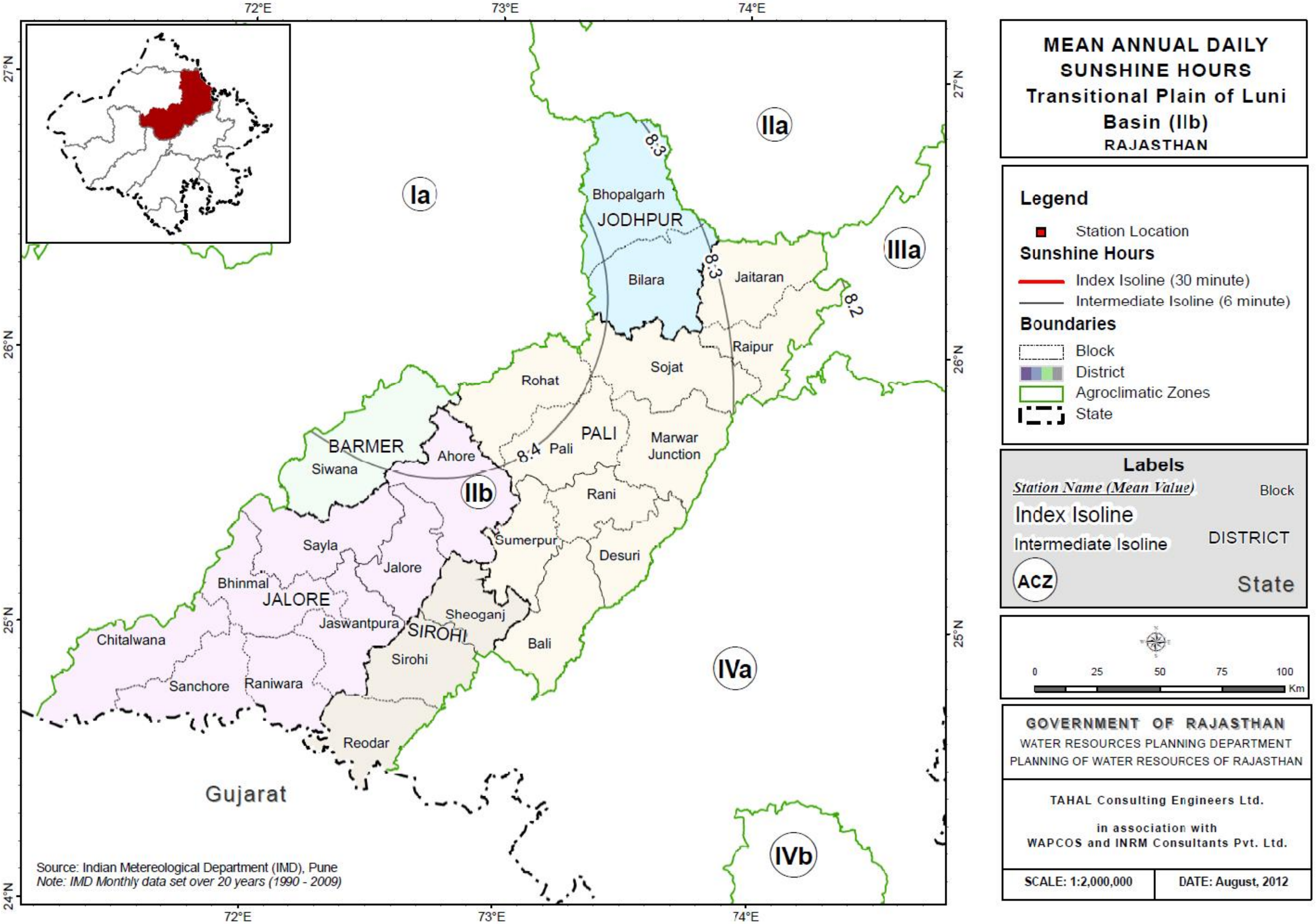
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL DAILY SUNSHINE HOURS
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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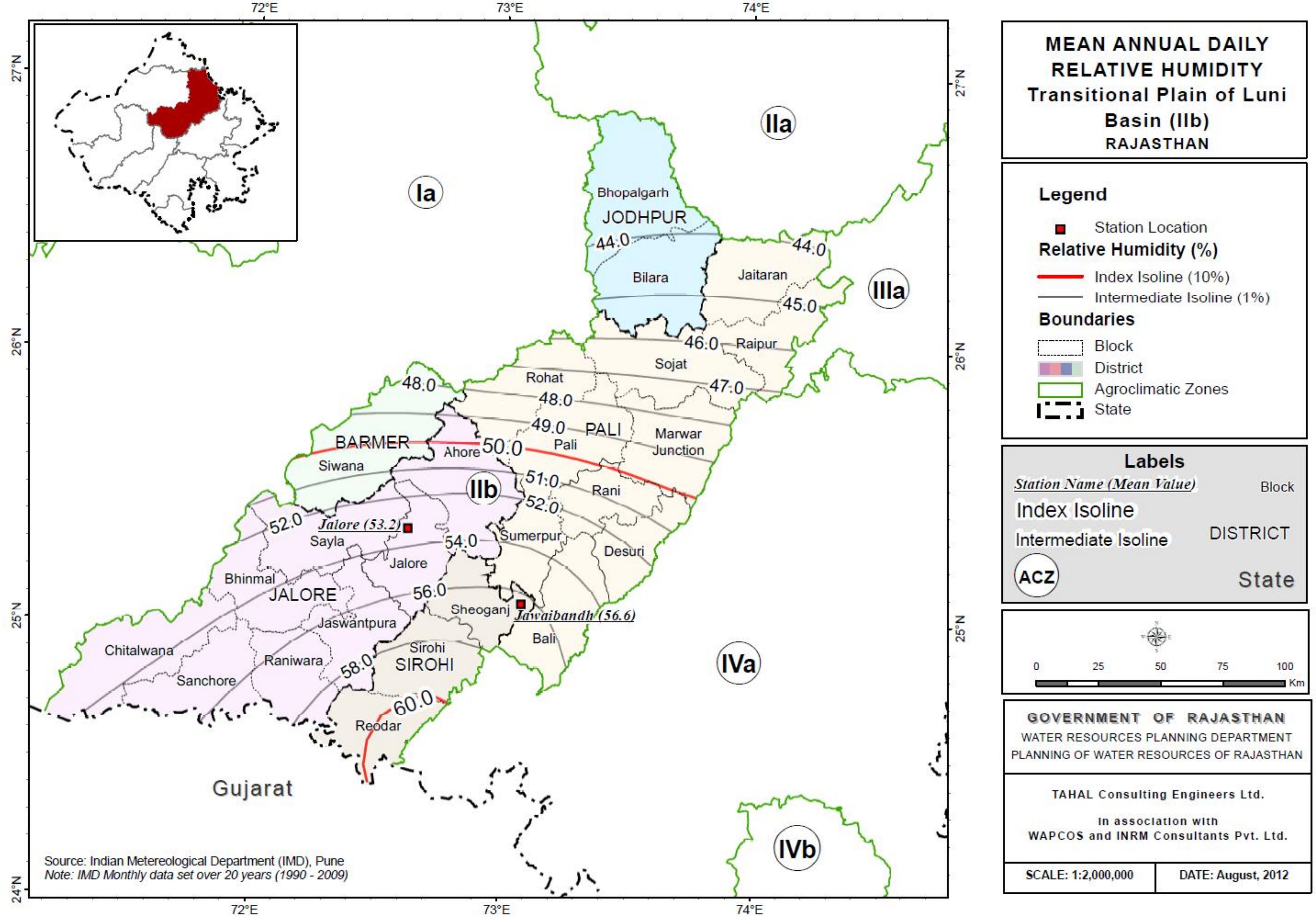

MEAN ANNUAL DAILY RELATIVE HUMIDITY
Transitional Plain of Luni Basin (IIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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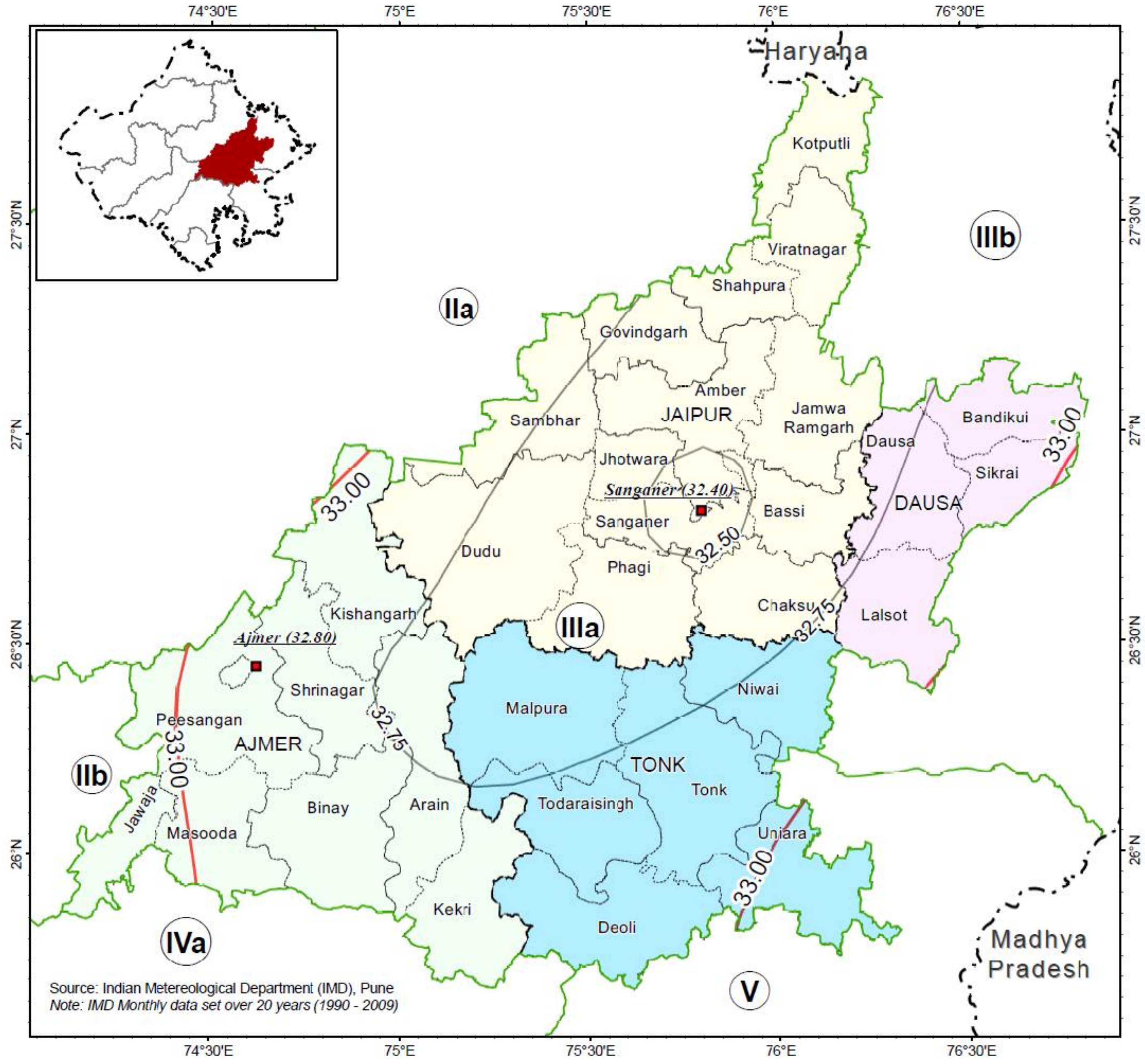
SCALE: 1:2,000,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE

Semi Arid Eastern Plain (IIIa)

RAJASTHAN

Legend

■ Station Location

Maximum Temperature (°C)

Index Isoline (1.0°C)

Intermediate Isoline (0.25°)

Boundaries

Block

District

Agroclimatic Zones

Rajasthan

Labels

Station Name (Mean Value) Block

Index Isoline

Intermediate Isoline DISTRICT

ACZ State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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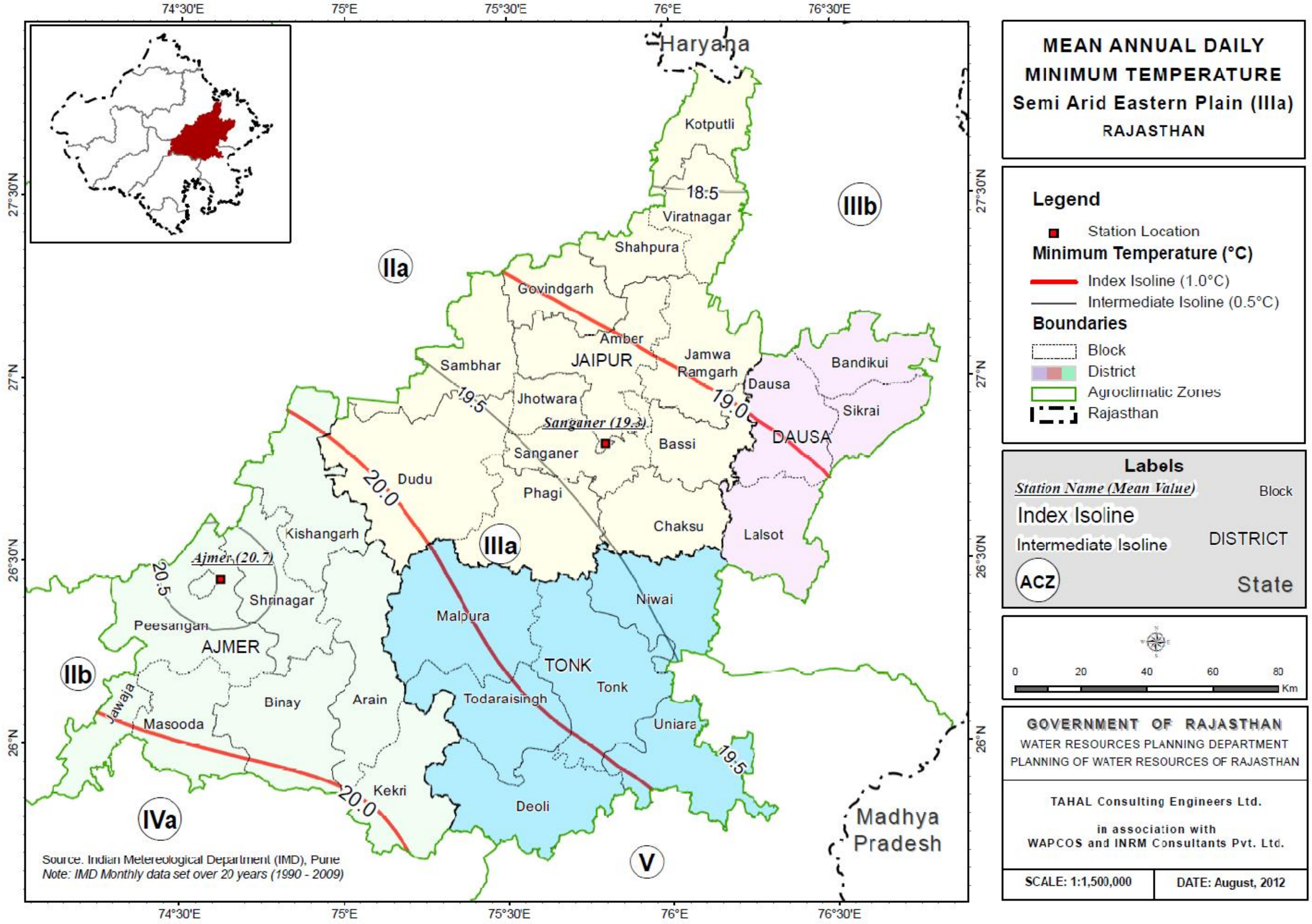
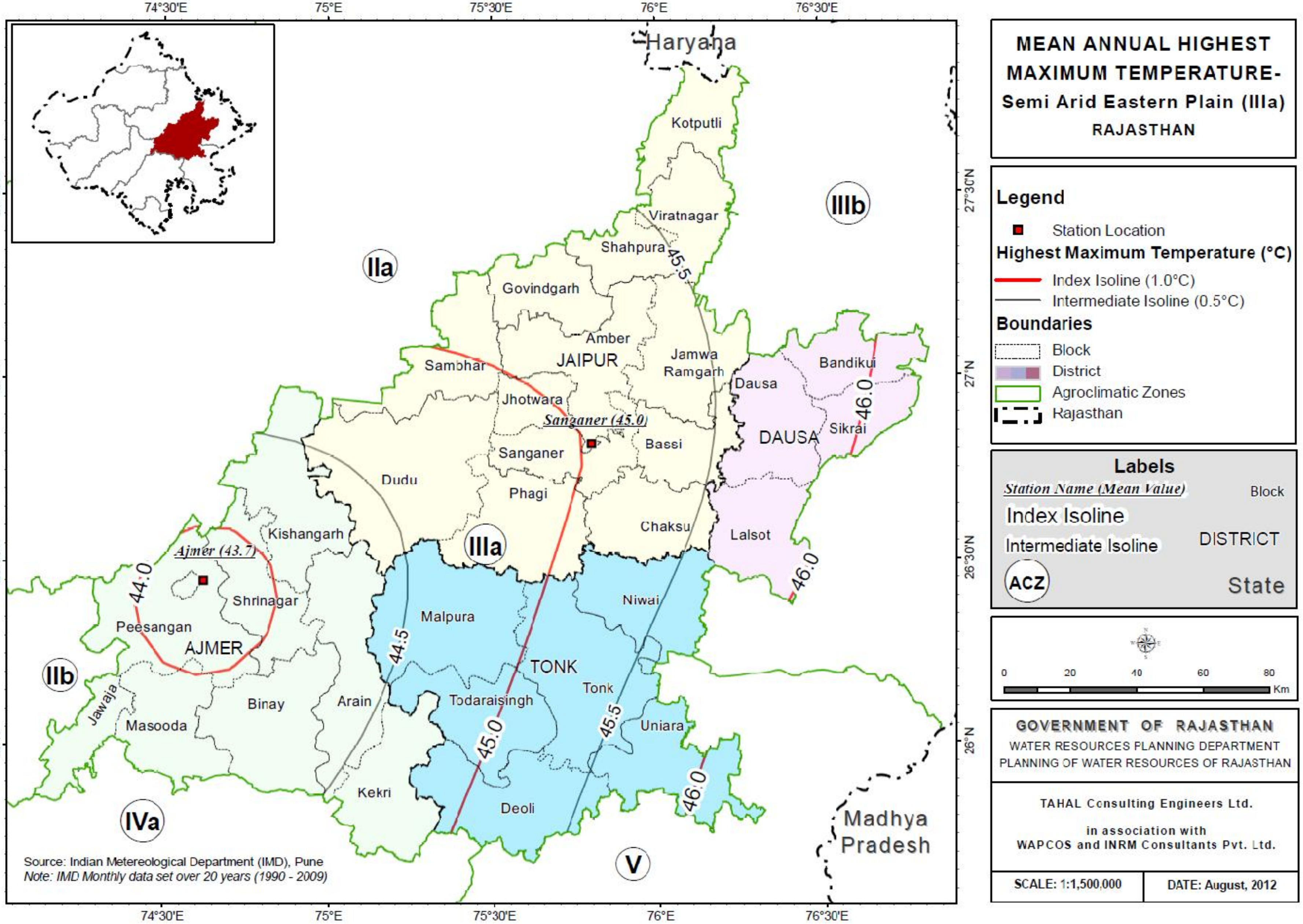
SCALE: 1:1,500,000	DATE: August, 2012


MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Semi Arid Eastern Plain (IIIa)
RAJASTHAN
Legend
Station Location
Minimum Temperature (°C)
Index Isoline (1.0°C)
Intermediate Isoline (0.5°C)
Boundaries
Block
District
Agroclimatic Zones
Rajasthan
Labels
Station Name (Mean Value)
Block
Index Isoline
Intermediate Isoline
DISTRICT
ACZ
State
0
20
40
60
80
Km
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN
TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.
SCALE: 1:1,500,000
DATE: August, 2012
74°30'E
75°E
75°30'E
76°E
76°30'E
27°30'N
27°N
26°30'N
26°N
Haryana
Madhya Pradesh
IIa
IIb
IIIa
IIIb
IVa
V
JAIPUR
DAUSA
AJMER
TONK
Kotputli
Viratnagar
Shahpura
Govindgarh
Amber
Jamwa Ramgarh
Sambhar
Jhotwara
Sanganer (19.3)
Sanganer
Bassi
Dudu
Phagi
Chaksu
Dausa
Bandikui
Sikrai
Lalsot
Kishangarh
Ajmer (20.7)
Shrinagar
Peesangan
Jawaja
Masooda
Binay
Arain
Kekri
Malpura
Niwai
Todaraisingh
Tonk
Uniara
Deoli
18.5
19.0
19.5
20.0
20.5
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Semi Arid Eastern Plain (IIIa)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
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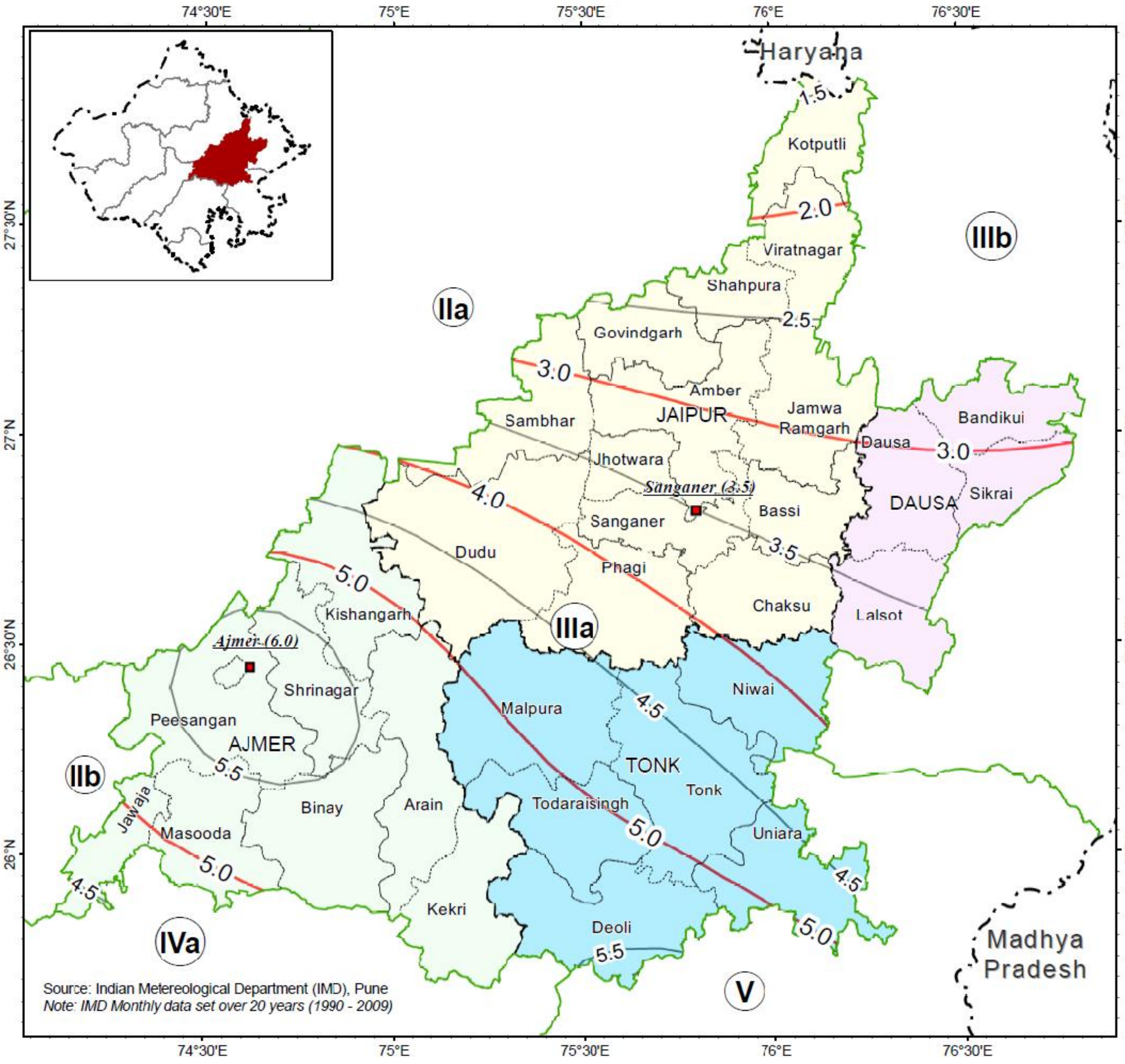
SCALE: 1:1,500,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL LOWEST MINIMUM TEMPERATURE- Semi Arid Eastern Plain (IIIa)
RAJASTHAN

Legend

🟥 Station Location

Lowest Minimum Temperature (°C)

—	Index Isoline (1.0°C)
—	Intermediate Isoline (0.5°C)

Boundaries

⬚	Block
▨	District
🟩	Agroclimatic Zones
⬚	Rajasthan

Labels

Station Name (Mean Value) Block
Index Isoline
Intermediate Isoline DISTRICT
ACZ State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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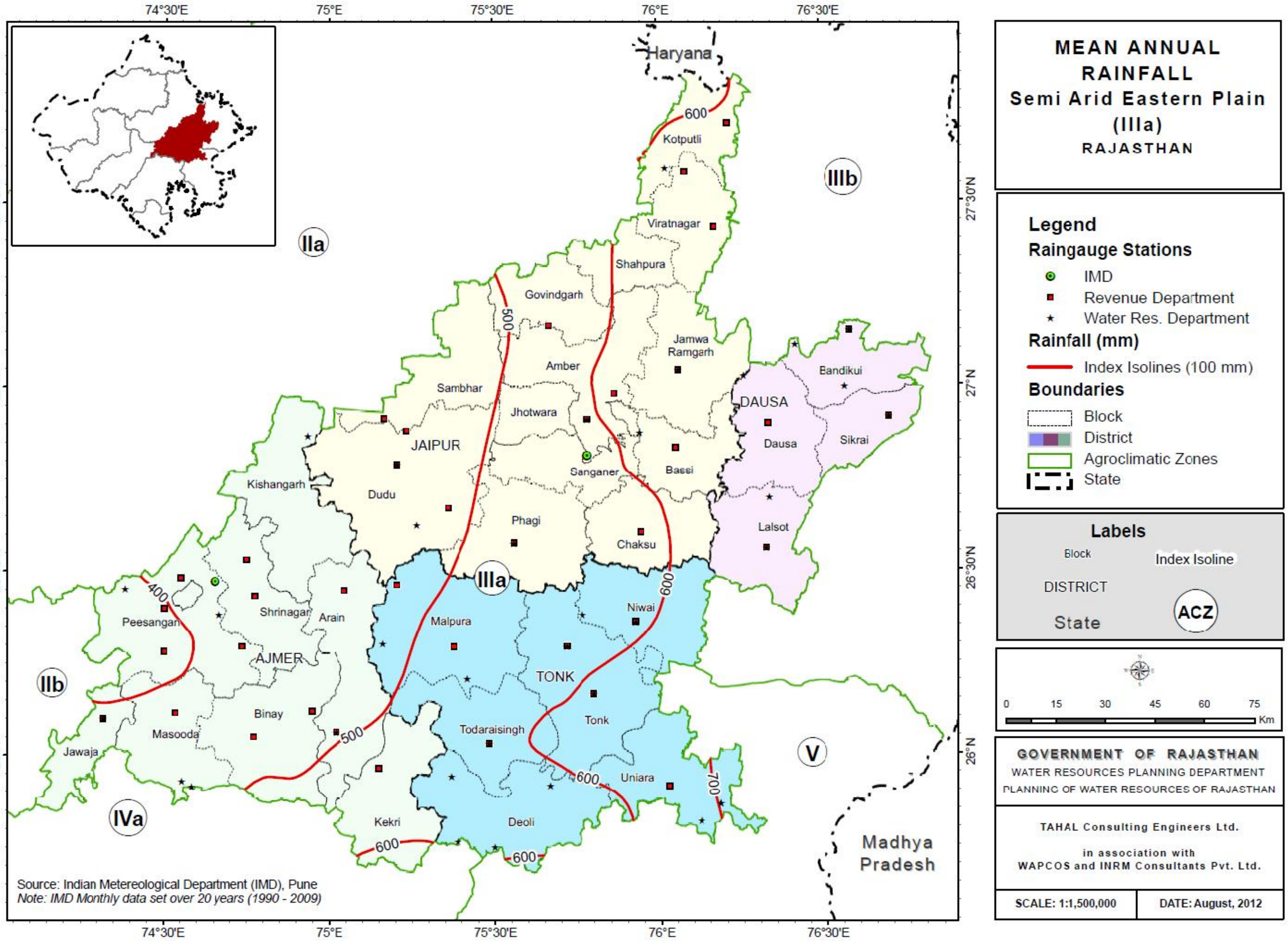
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,500,000	DATE: August, 2012



MEAN ANNUAL RAINFALL
Semi Arid Eastern Plain (IIIa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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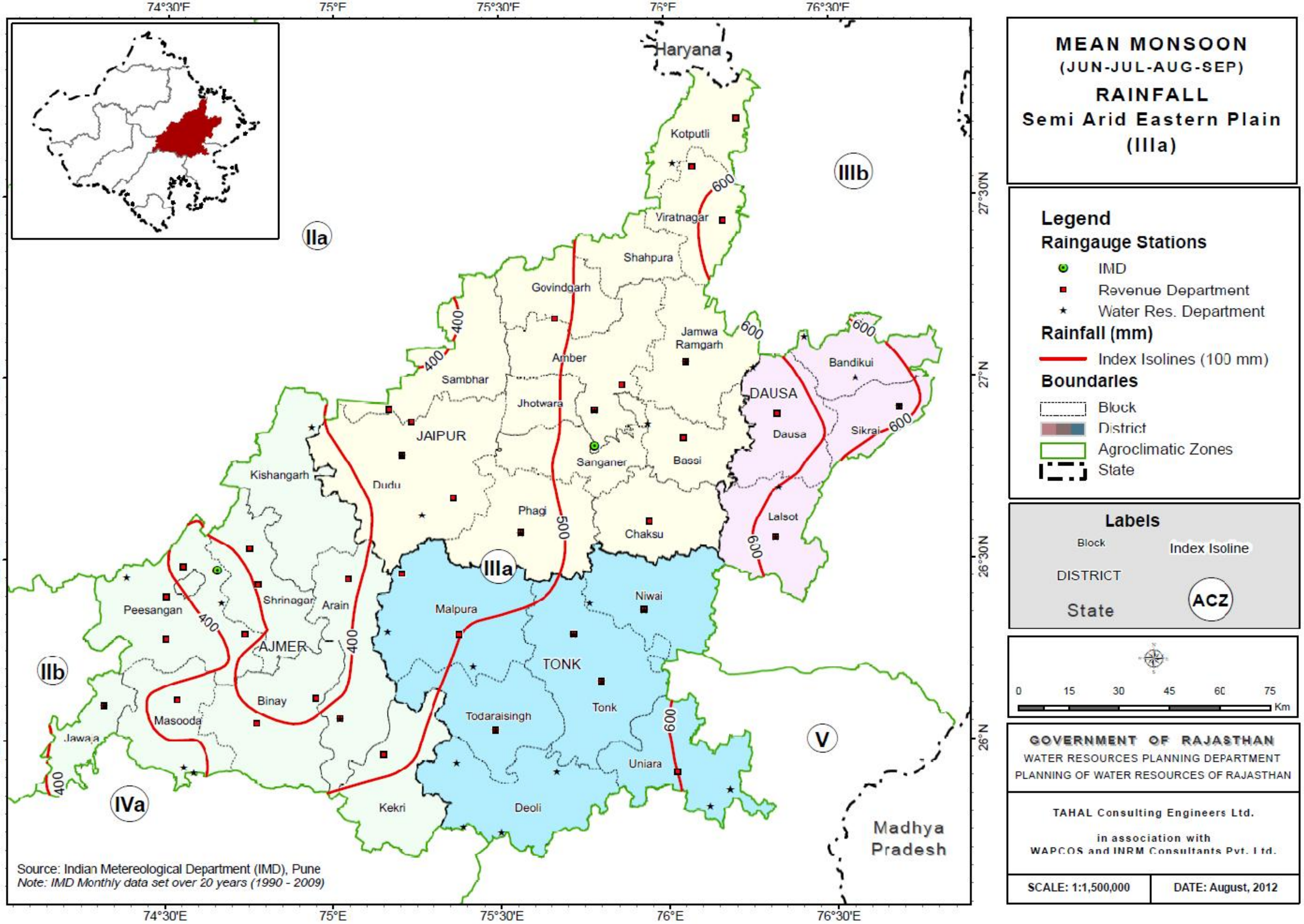
SCALE: 1:1,500,000
DATE: August, 2012



MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Semi Arid Eastern Plain
(IIIa)

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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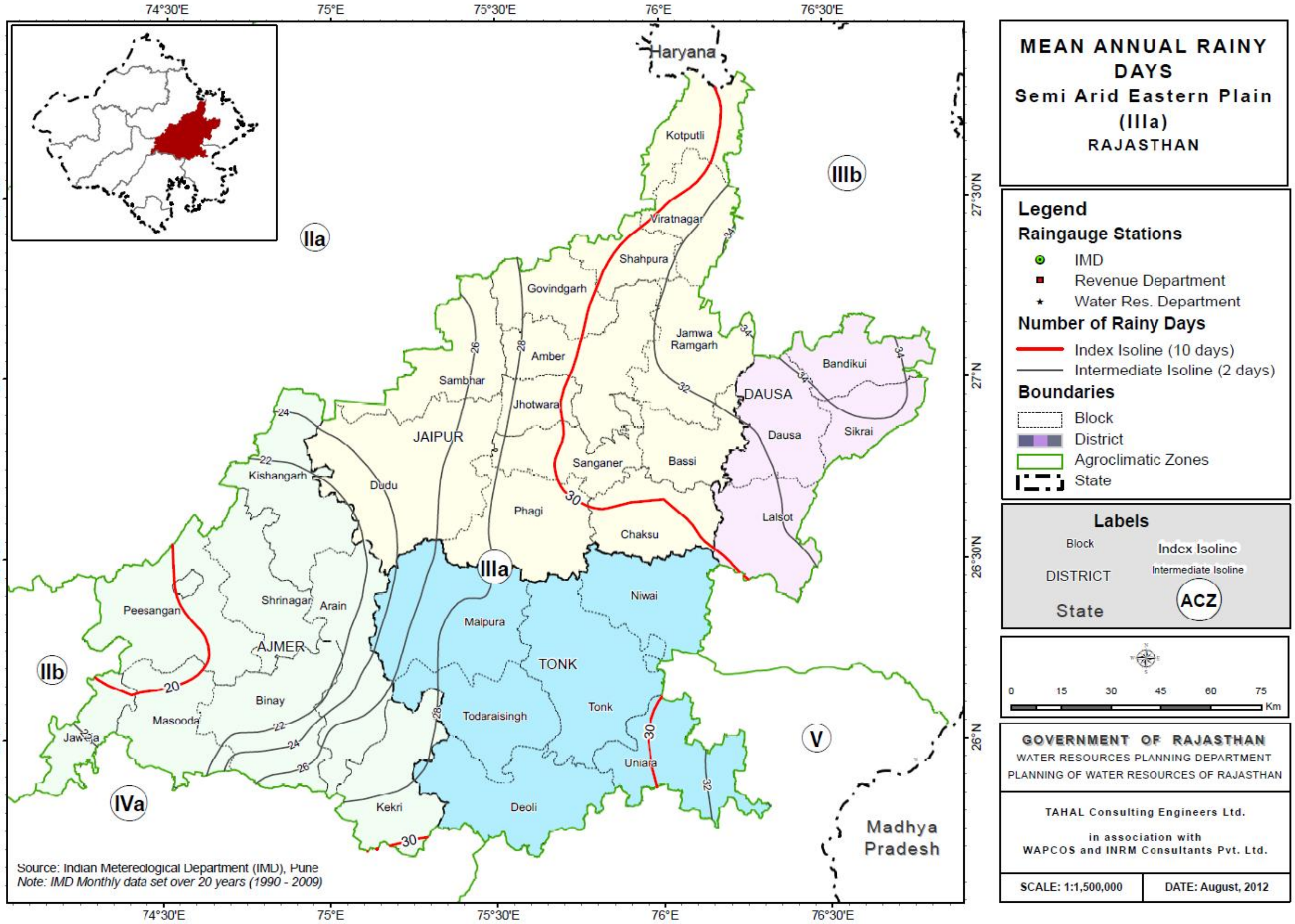
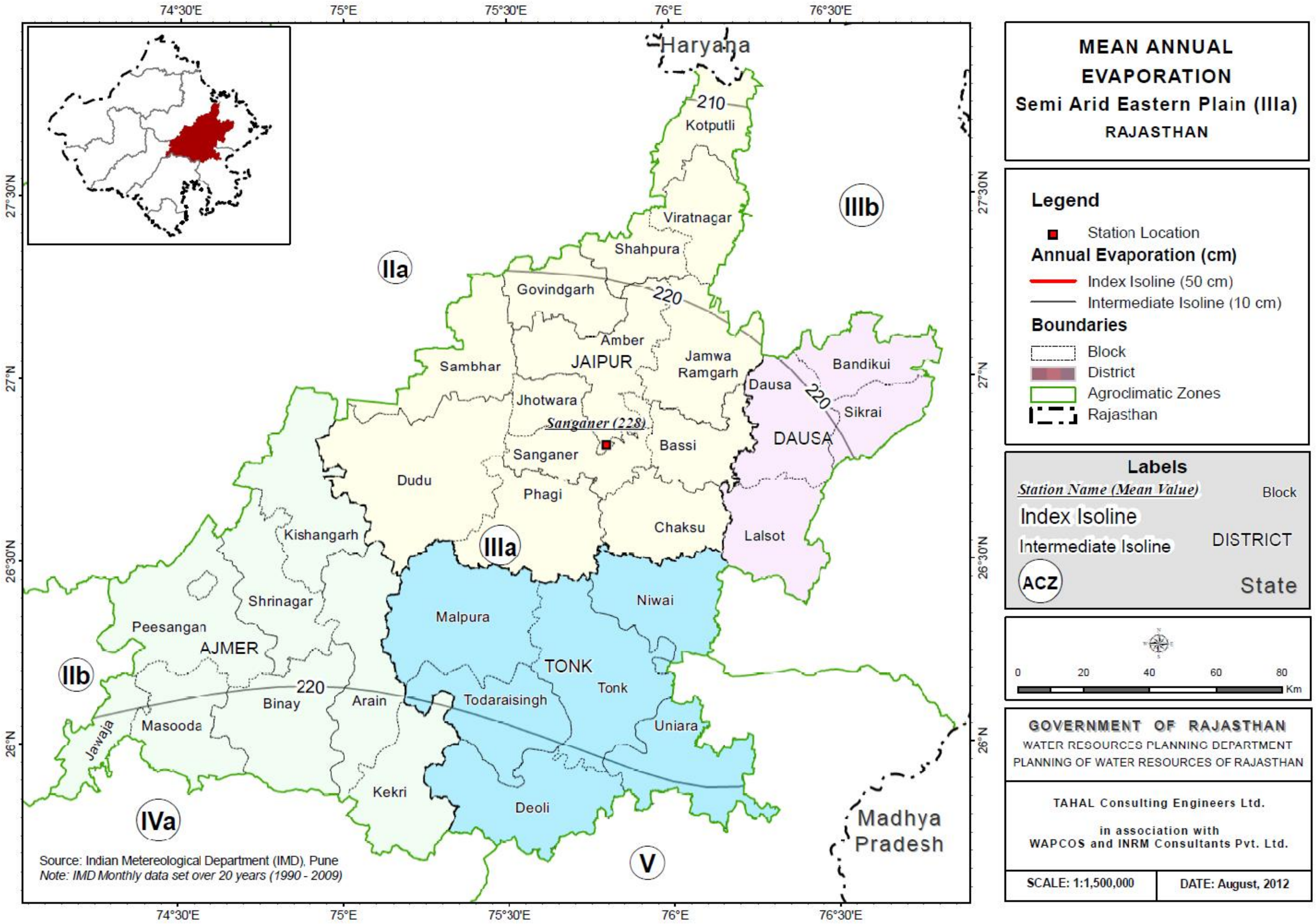
SCALE: 1:1,500,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL EVAPORATION
Semi Arid Eastern Plain (IIIa)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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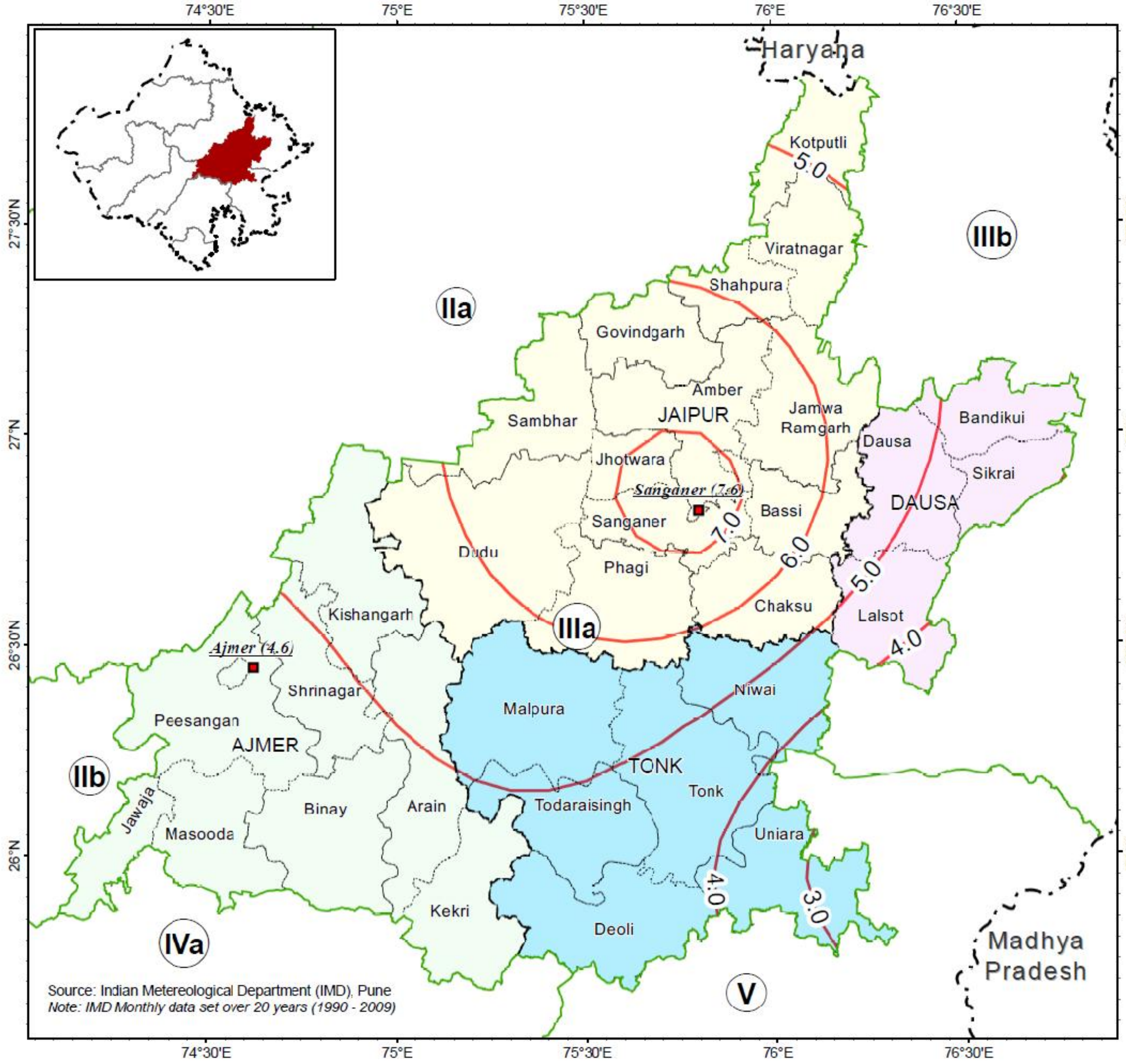
SCALE: 1:1,500,000

DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED
Semi Arid Eastern Plain (IIIa)
RAJASTHAN

Legend

■ Station Location

Windspeed (km/h)

— Index Isoline (1 km/h)

Boundaries

┆ Block

▨ District

▭ Agroclimatic Zones

┆ Rajasthan

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

ACZ State

0 20 40 60 80 Km

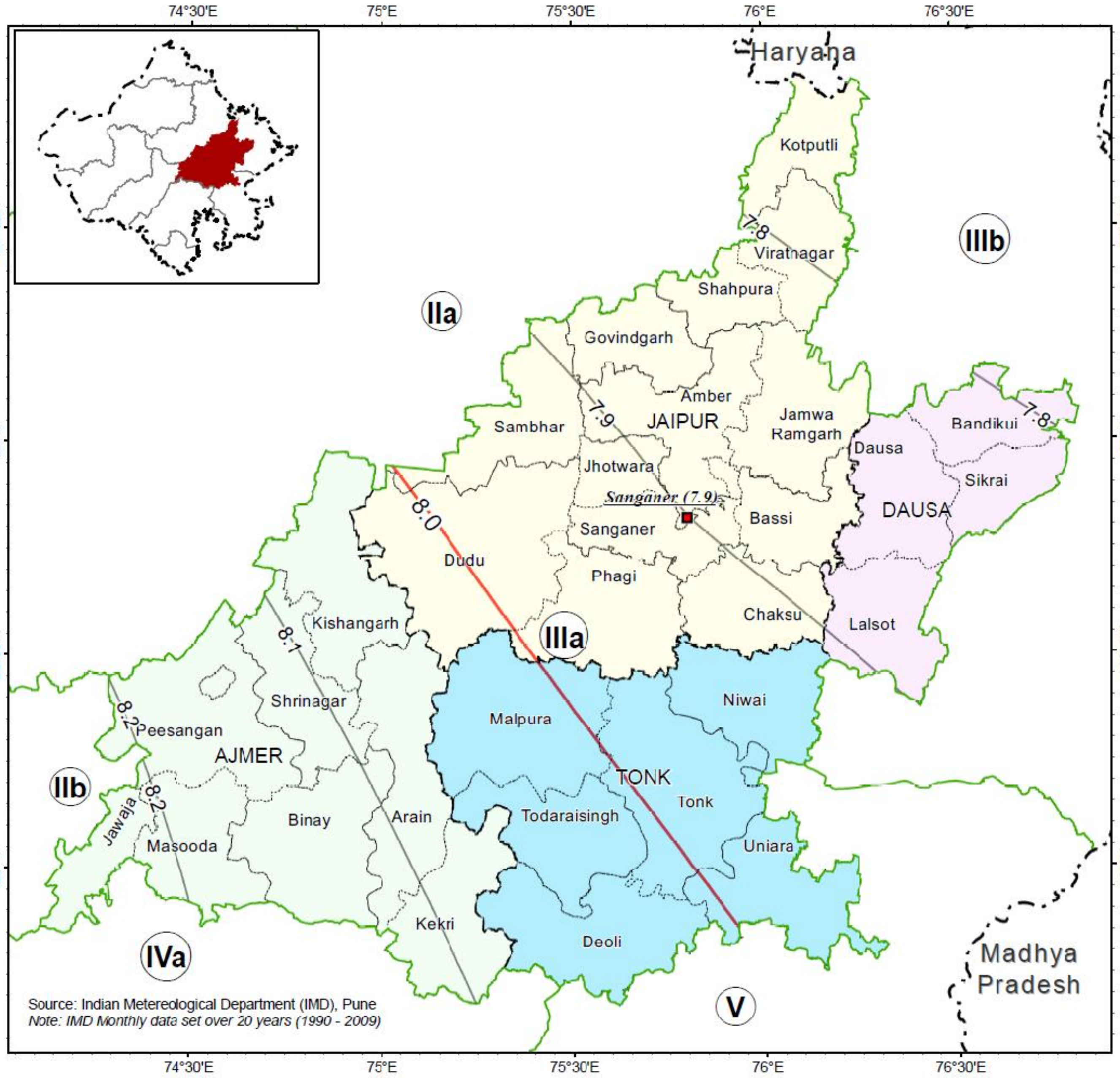
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,500,000

DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY SUNSHINE HOURS
Semi Arid Eastern Plain (IIIa)
RAJASTHAN

Legend

🟥 Station Location

Sunshine Hours

▬	Index Isoline (30 minute)
—	Intermediate Isoline (6 minute)

Boundaries

⬚	Block
▨	District
▭	Agroclimatic Zones
⬚	Rajasthan

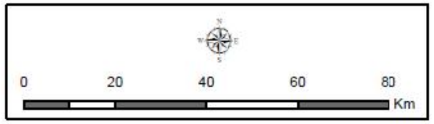
Labels

Station Name (Mean Value) Block

Index Isoline

Intermediate Isoline DISTRICT

ACZ State



GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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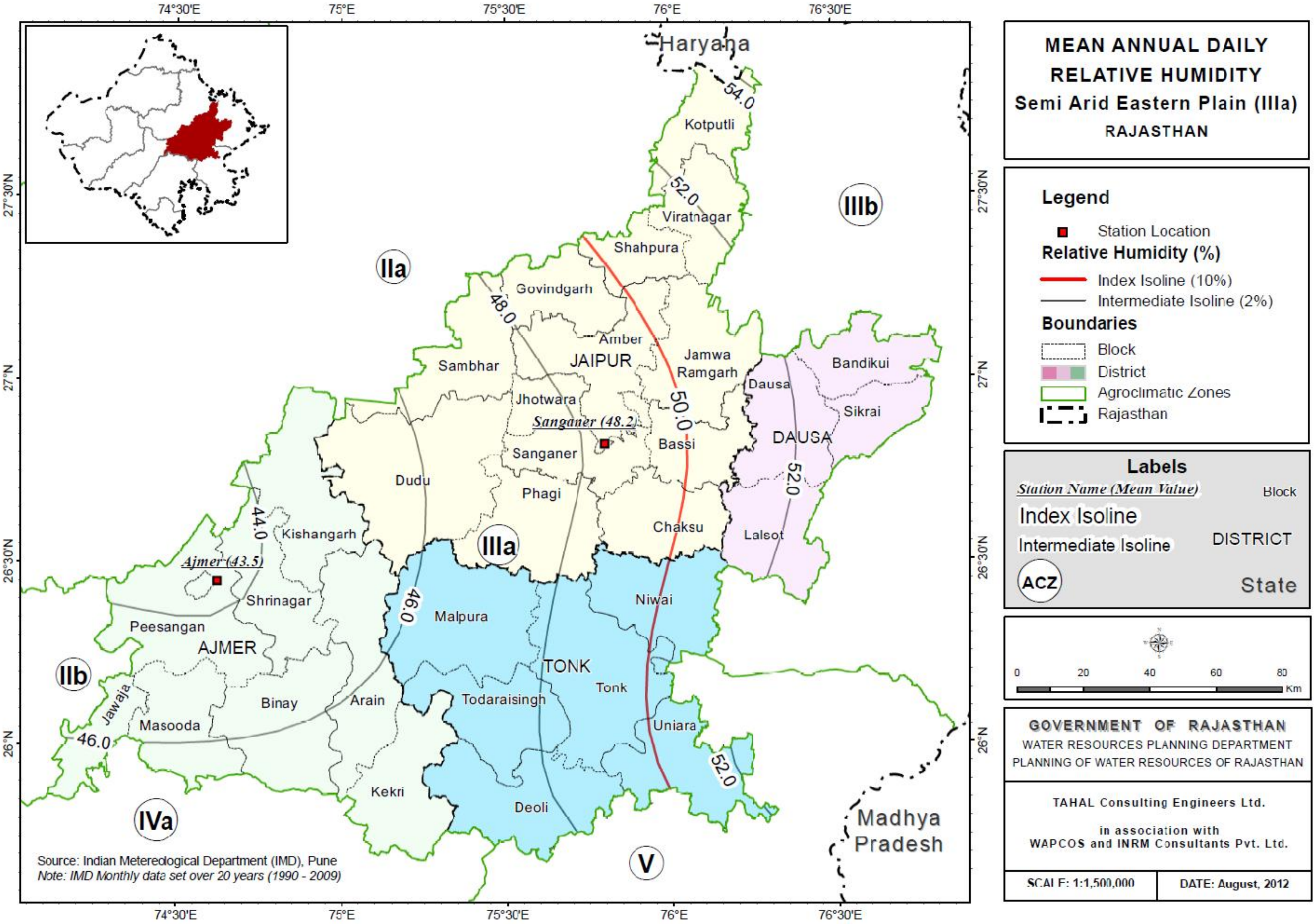
SCALE: 1:1,500,000 | DATE: August, 2012



MEAN ANNUAL DAILY RELATIVE HUMIDITY
Semi Arid Eastern Plain (IIIa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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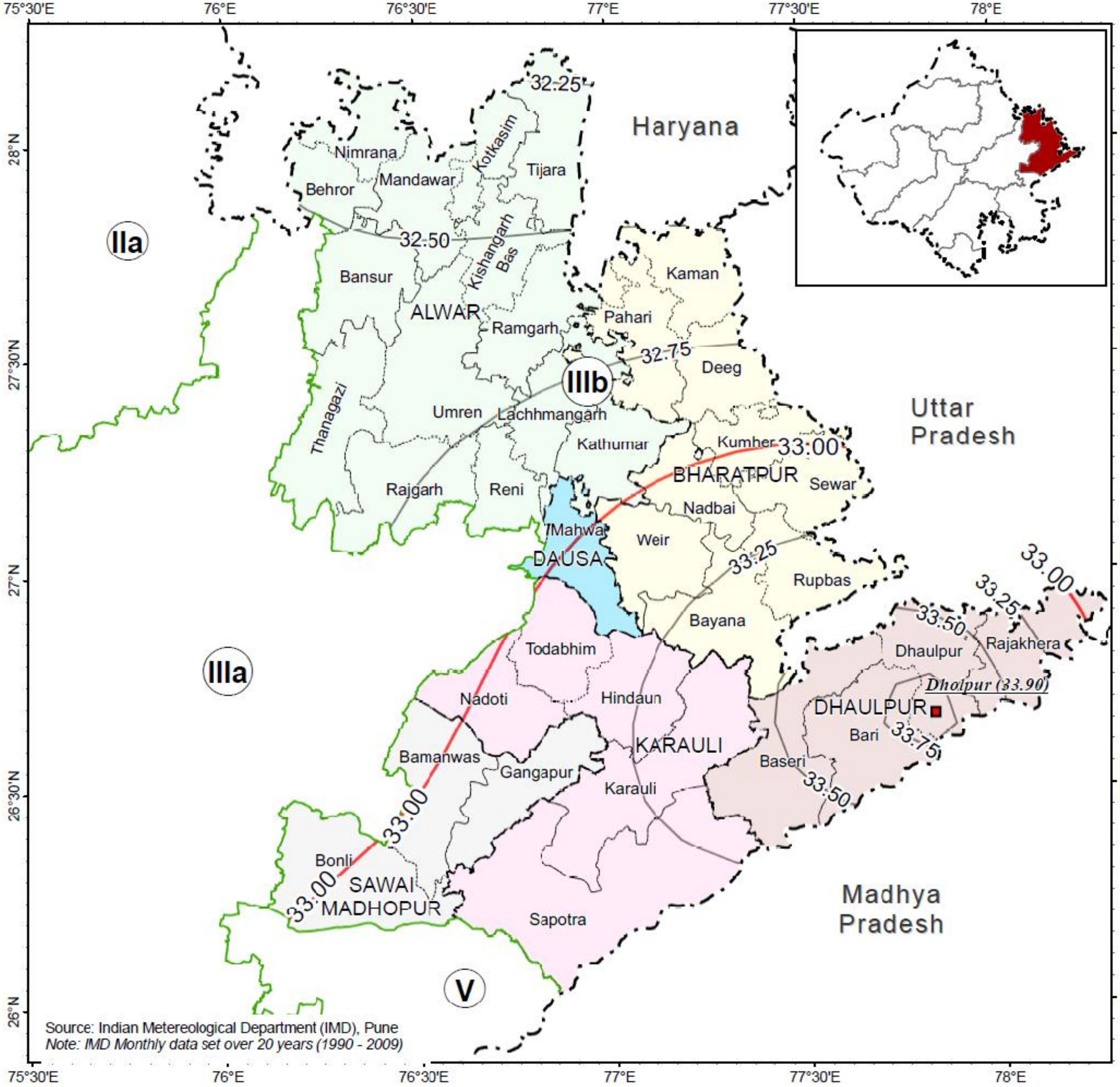
SCALE: 1:1,500,000
DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Flood Prone Eastern Plain (IIIb)
RAJASTHAN

Legend

■ Station Location

Maximum Temperature (°C)

— Index Isoline (1.0°C)
— Intermediate Isoline (0.25°)

Boundaries

☐ Block
▨ District
☐ Agroclimatic Zones
☐ State

Labels

Station Name (Mean Value) — Block
Index Isoline — DISTRICT
Intermediate Isoline
ACZ — State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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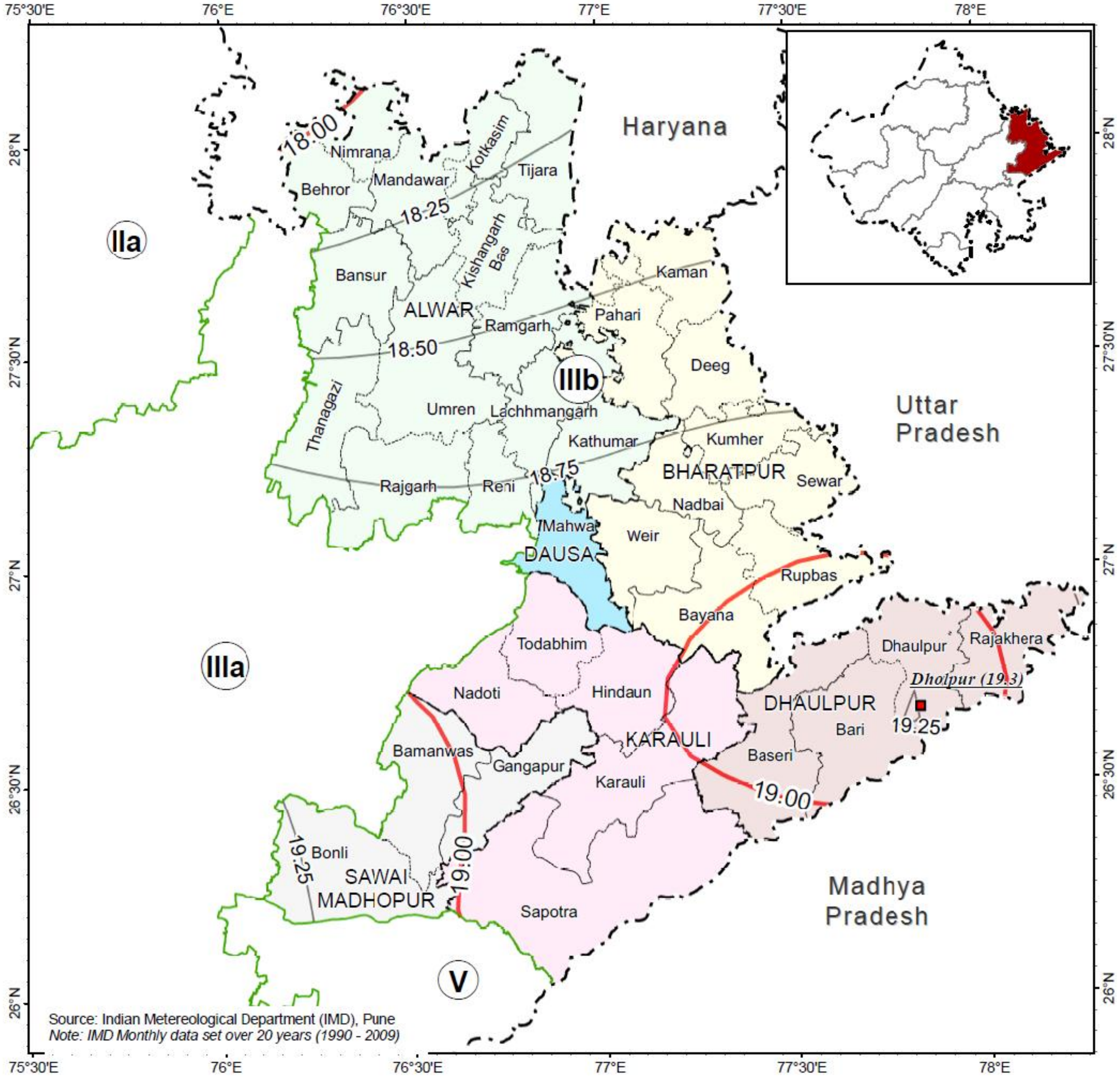
SCALE: 1:1,500,000	DATE: August, 2012

MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Flood Prone Eastern Plain (IIIb)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

■	Station Location
Minimum Temperature (°C)	
▬	Index Isoline (1.0°C)
—	Intermediate Isoline (0.25°C)
Boundaries	
⬚	Block
▨	District
🟩	Agroclimatic Zones
⬚	State

Labels

Station Name (Mean Value)	Block
Index Isoline	
Intermediate Isoline	DISTRICT
ACZ	State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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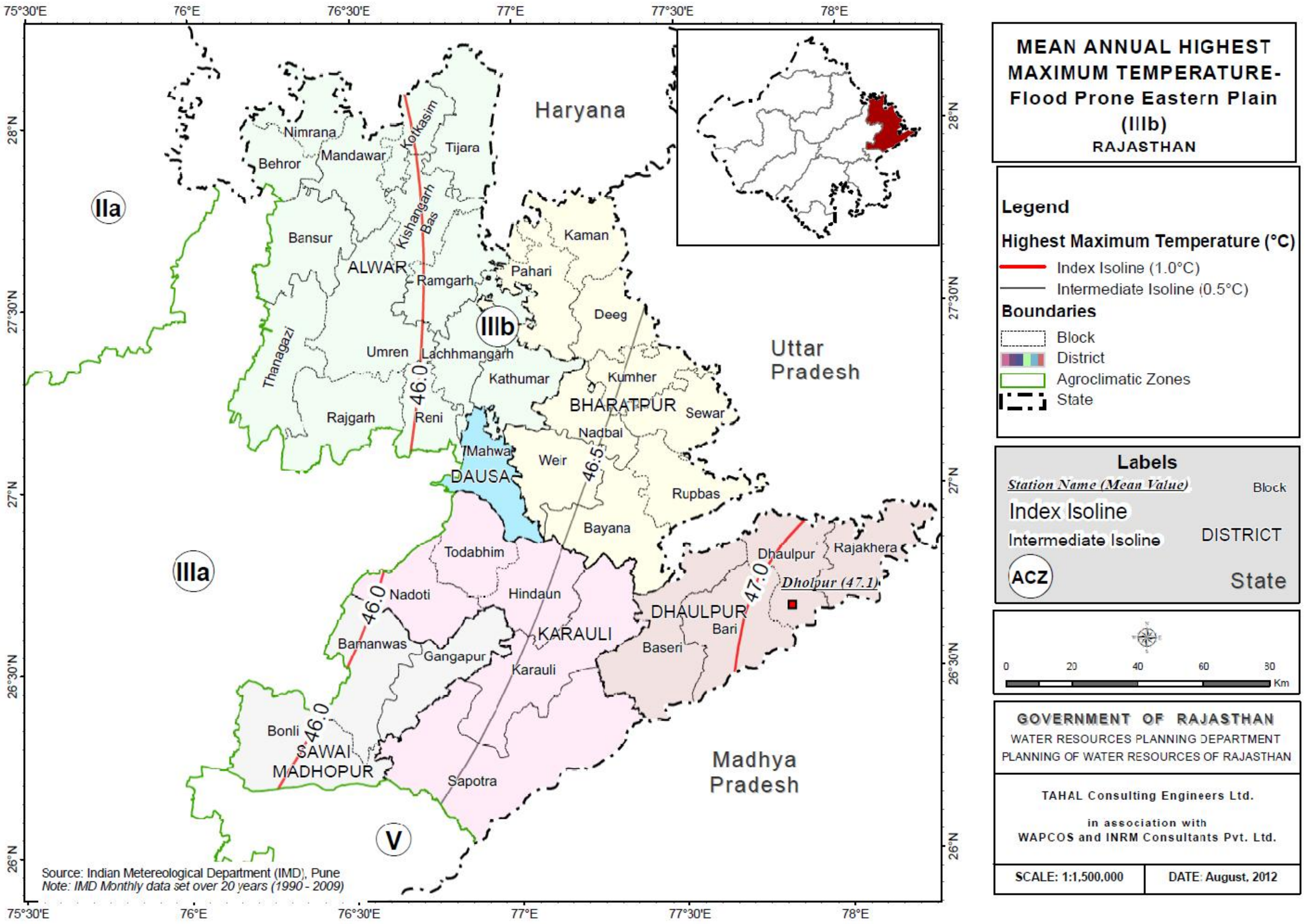
SCALE: 1:1,500,000	DATE: August, 2012



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Flood Prone Eastern Plain (IIIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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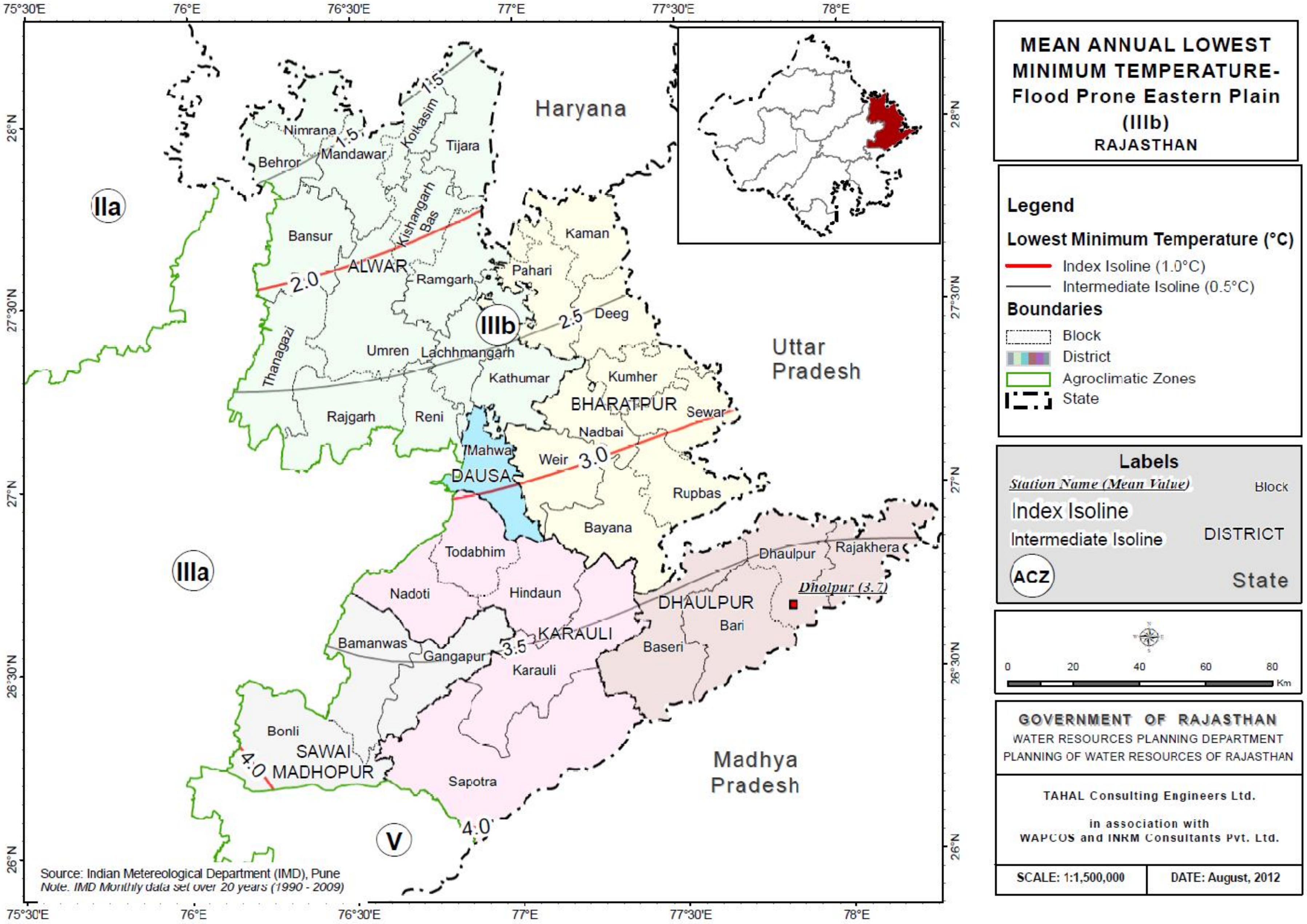
SCALE: 1:1,500,000
DATE: August, 2012



MEAN ANNUAL LOWEST MINIMUM TEMPERATURE- Flood Prone Eastern Plain (IIIb)
RAJASTHAN

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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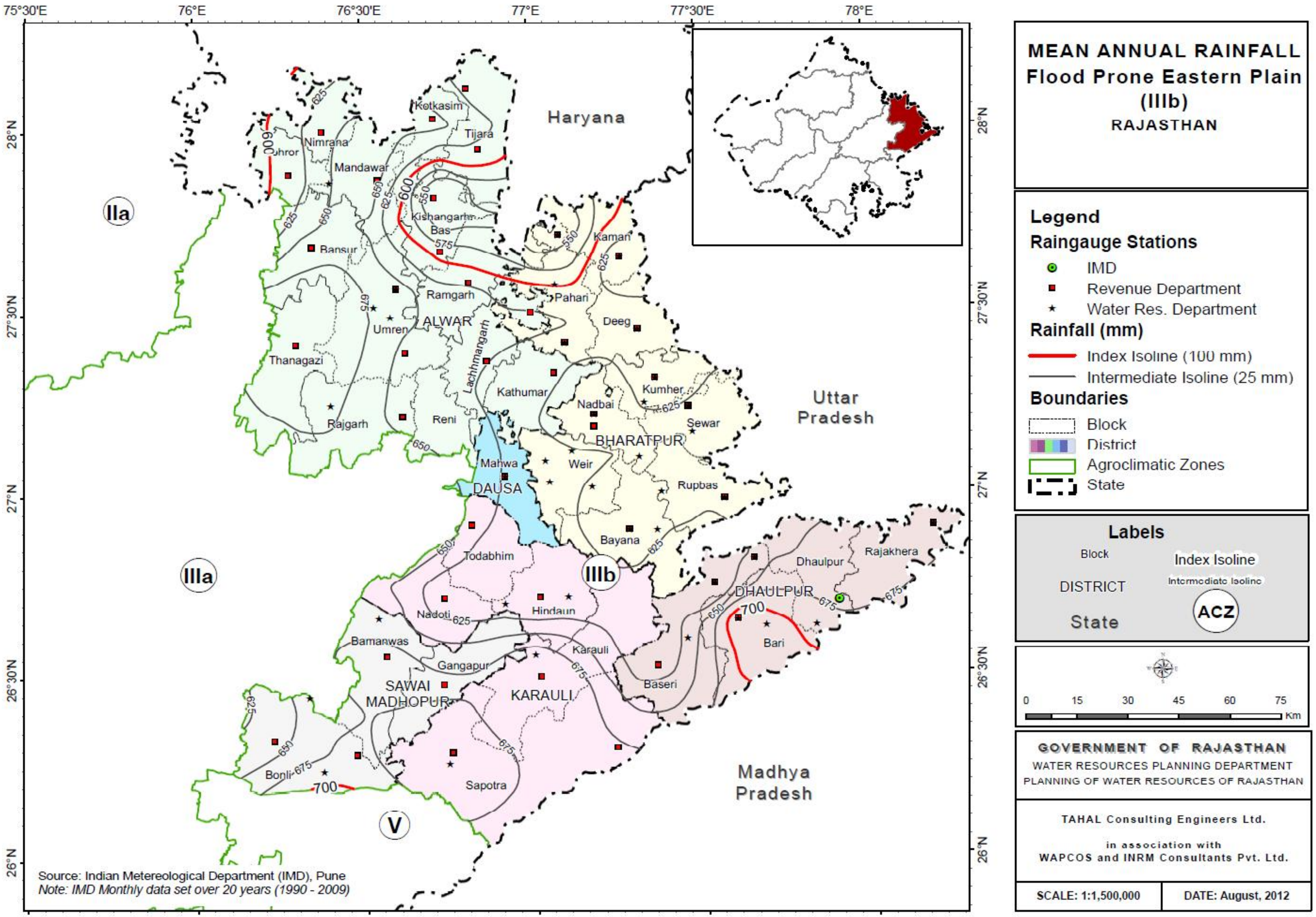
SCALE: 1:1,500,000 | DATE: August, 2012



MEAN ANNUAL RAINFALL
Flood Prone Eastern Plain (IIIb)
RAJASTHAN

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

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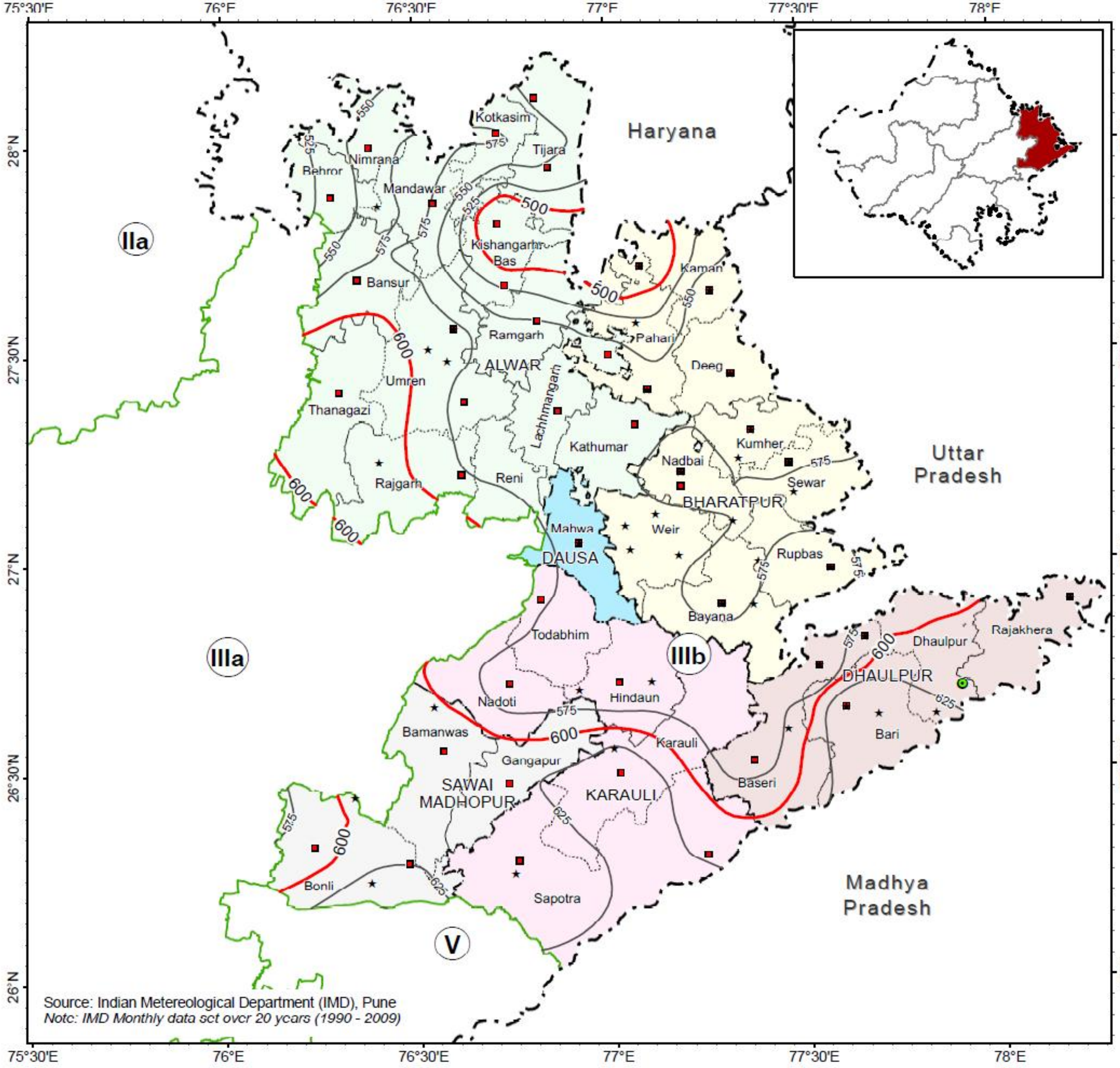
SCALE: 1:1,500,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Flood Prone Eastern Plain (IIIb)
RAJASTHAN

Legend

Raingauge Stations

⊙	IMD
■	Revenue Department
★	Water Res. Department

Rainfall (mm)

━	Index Isoline (100 mm)
─	Intermediate Isoline (25 mm)

Boundaries

┈	Block
▨	District
🟩	Agroclimatic Zones
▭	State

Labels

Block

Index Isoline

DISTRICT

Intermediate Isoline

ACZ

State

0 15 30 45 60 75 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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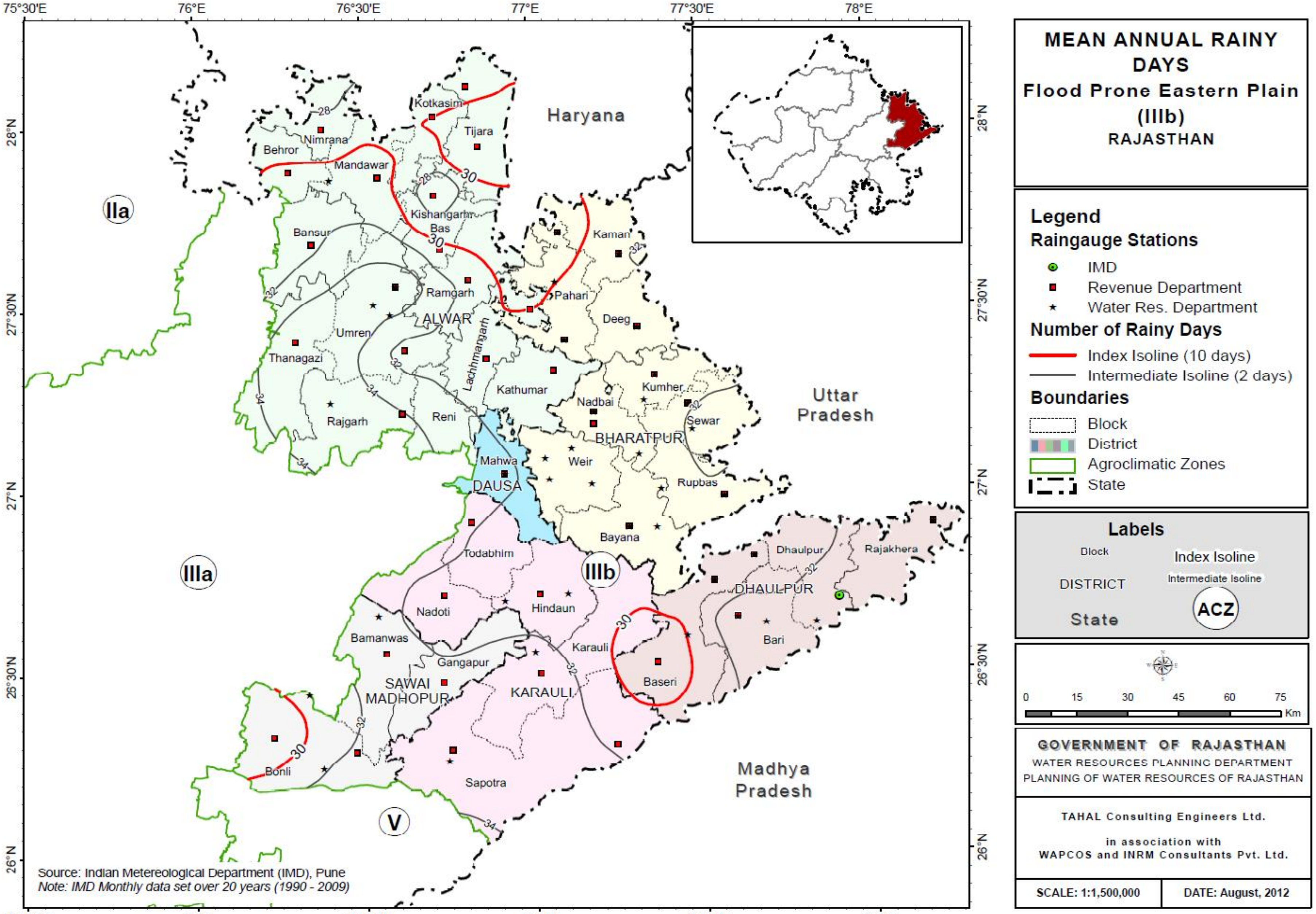
SCALE: 1:1,500,000

DATE: August, 2012



MEAN ANNUAL RAINY DAYS
Flood Prone Eastern Plain (IIIb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
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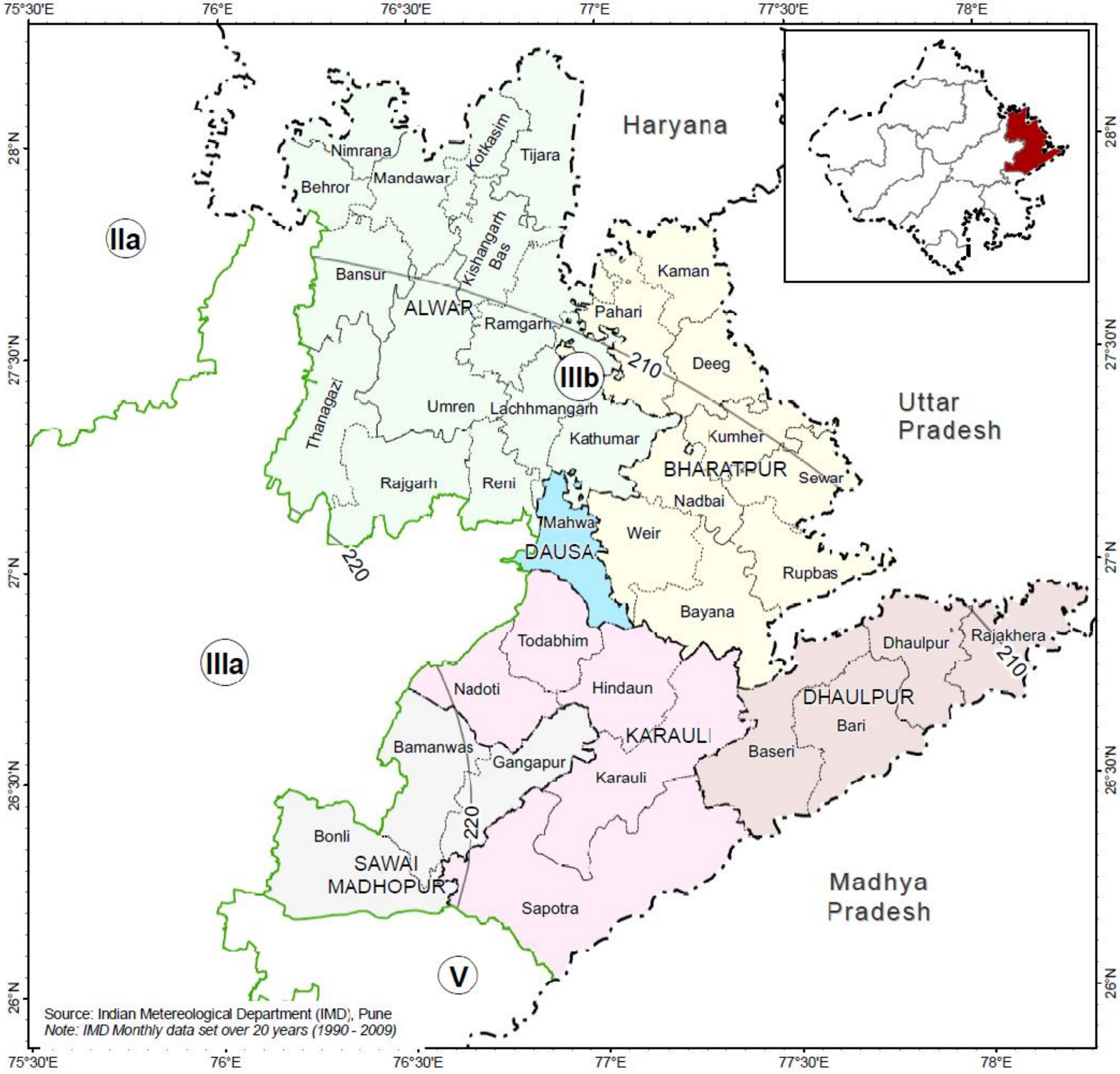
SCALE: 1:1,500,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL EVAPORATION
Flood Prone Eastern Plain (IIIb)
RAJASTHAN

Legend

■ Station Location

Annual Evaporation (cm)

Index Isoline (50 cm)

Intermediate Isoline (10 cm)

Boundaries

Block

District

Agroclimatic Zones

State

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

Intermediate Isoline

ACZ State

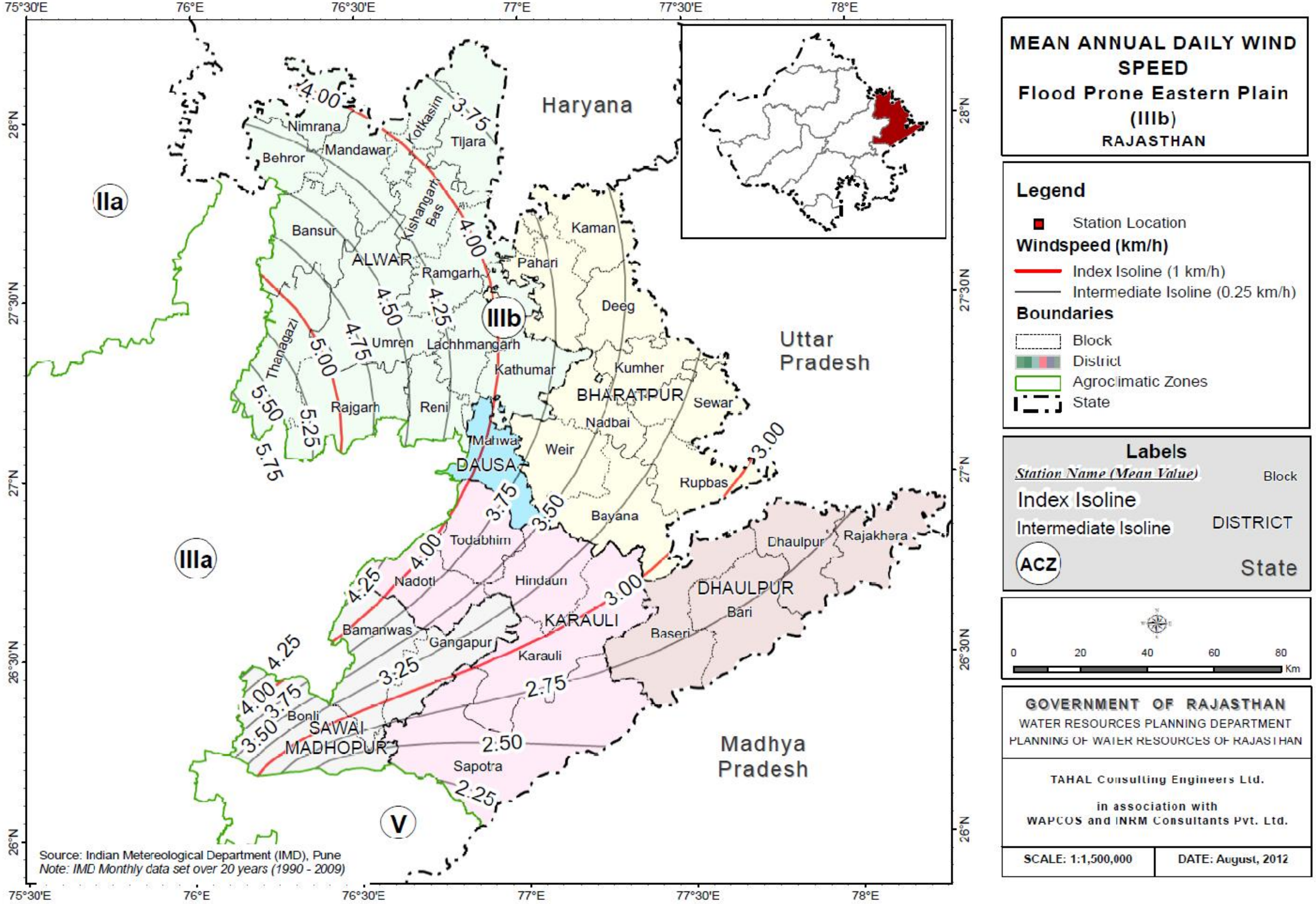
0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,500,000 DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED

Flood Prone Eastern Plain (IIIb)

RAJASTHAN

Legend

🟥 Station Location

Windspeed (km/h)

Index Isoline (1 km/h)

Intermediate Isoline (0.25 km/h)

Boundaries

Block

District

Agroclimatic Zones

State

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

Intermediate Isoline

ACZ State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN

WATER RESOURCES PLANNING DEPARTMENT

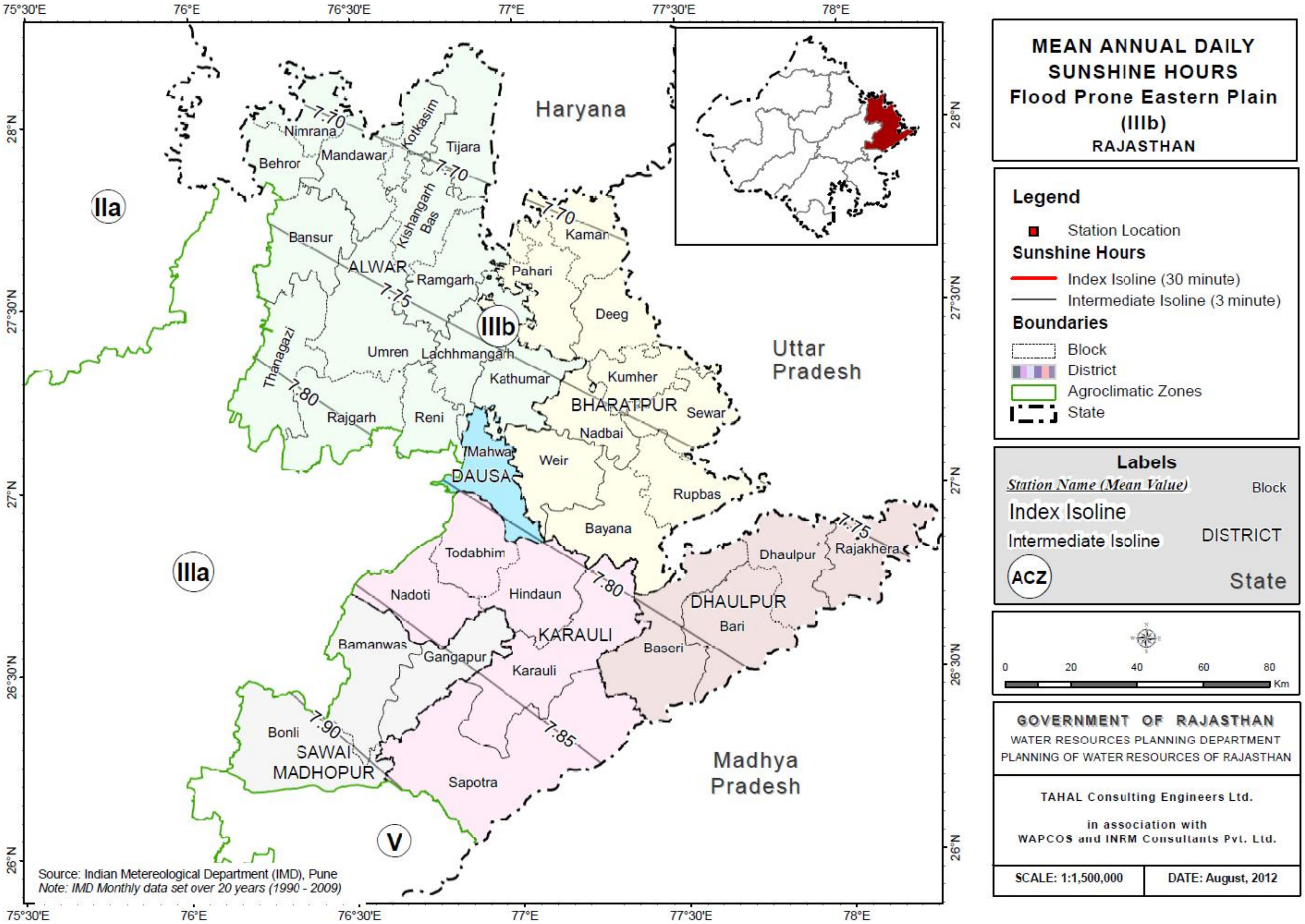
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with

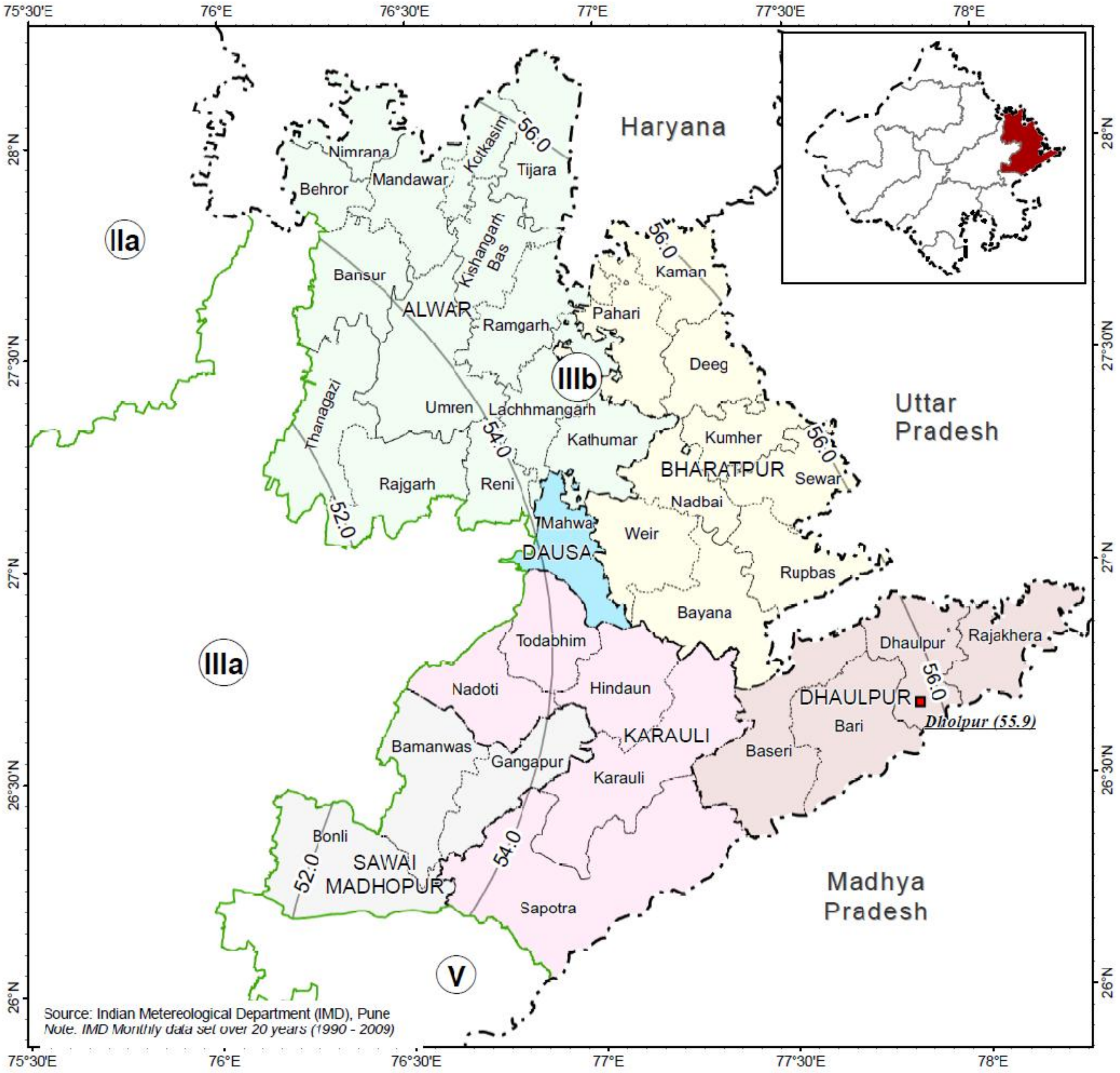
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,500,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY RELATIVE HUMIDITY
Flood Prone Eastern Plain (IIIb)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

■ Station Location

Relative Humidity (%)

- Index Isoline (10%)
- Intermediate Isoline (1%)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Station Name (Mean Value)
Block
Index Isoline
Intermediate Isoline
DISTRICT
ACZ
State

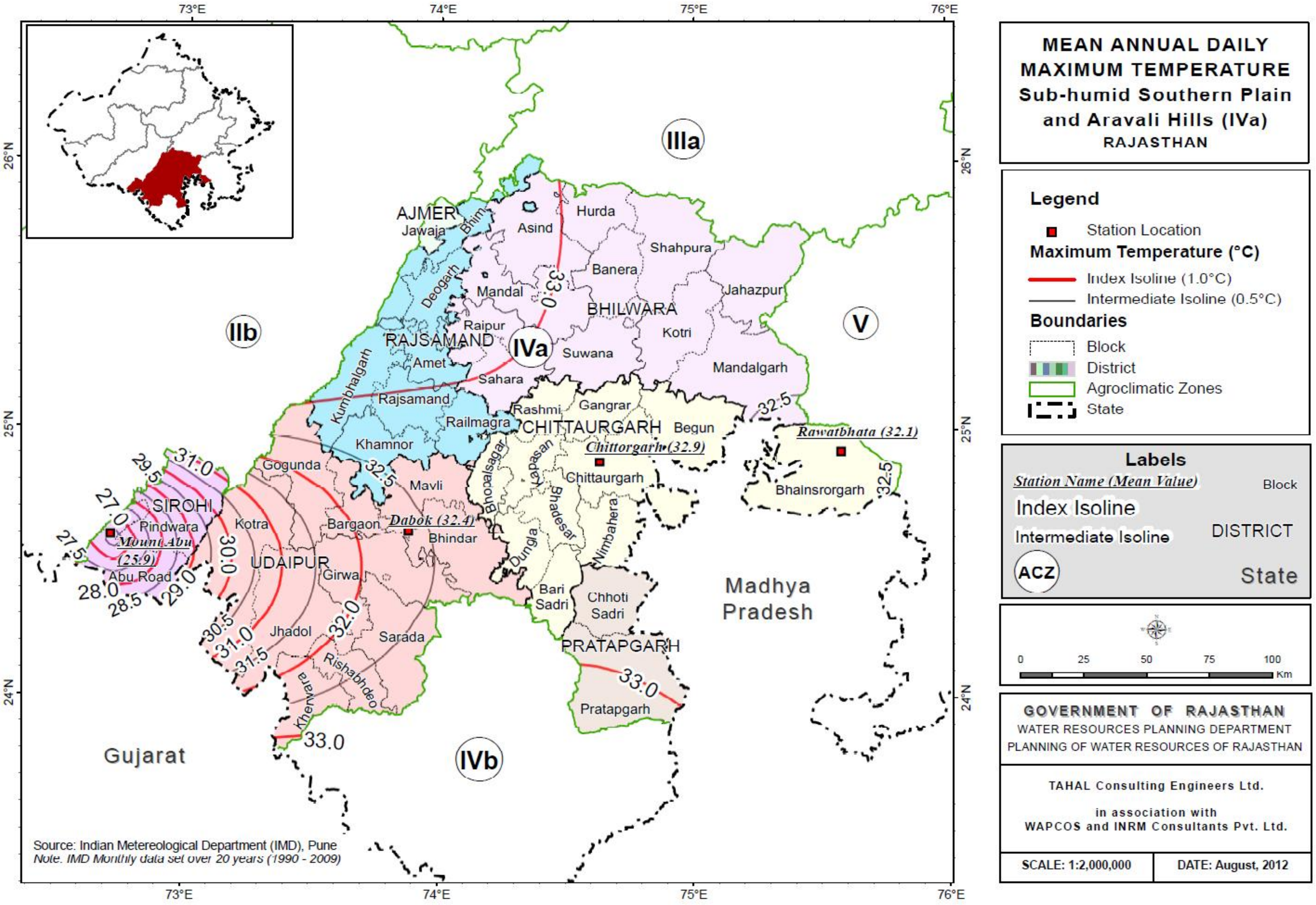
0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,500,000	DATE: August, 2012



MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

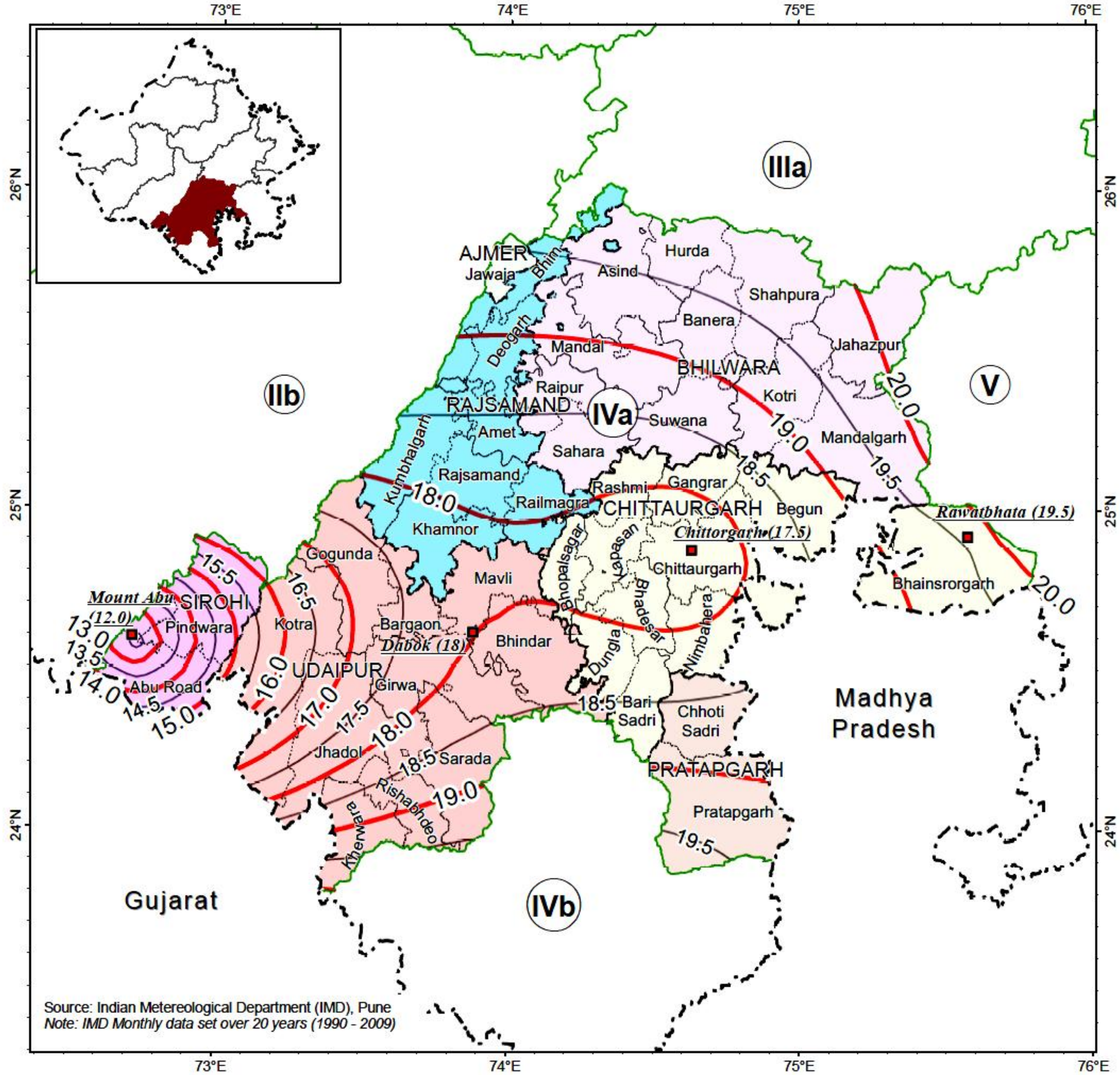
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000
DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

🟥 Station Location

Minimum Temperature (°C)

- Index Isoline (1.0°C)
- Intermediate Isoline (0.5°C)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Station Name (Mean Value)
Block
Index Isoline
DISTRICT
Intermediate Isoline
ACZ
State

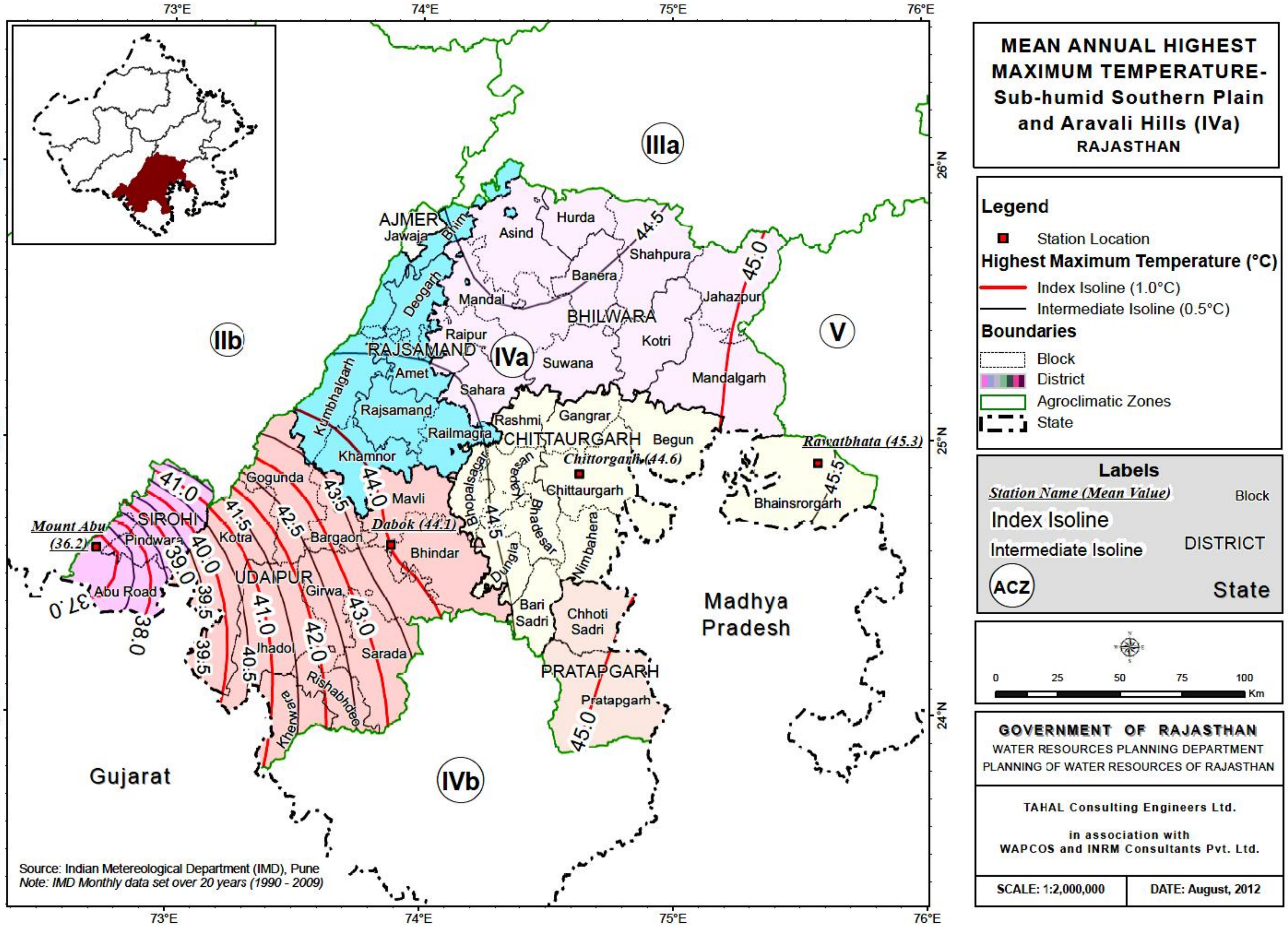
0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000	DATE: August, 2012



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
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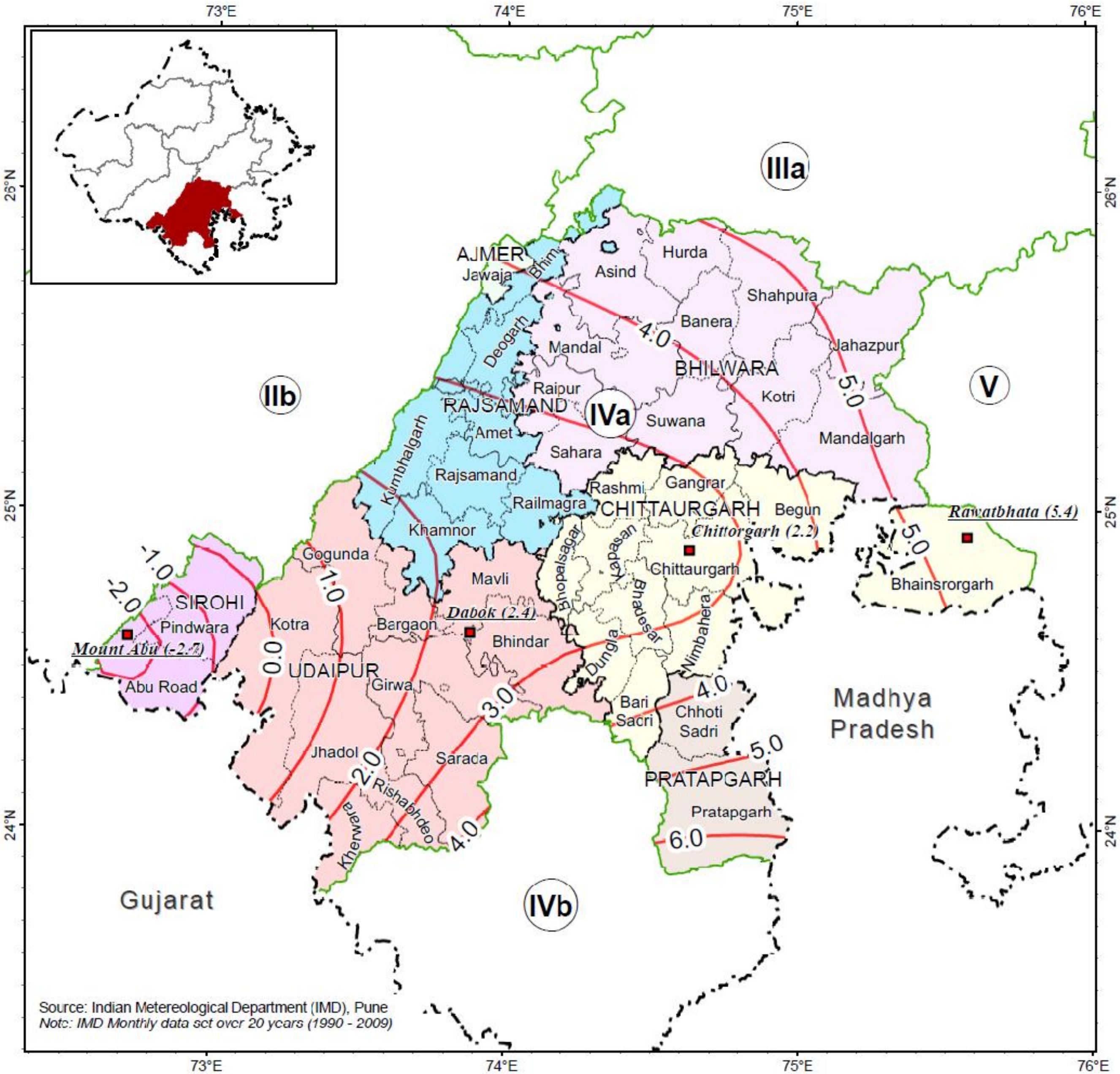
SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL LOWEST MINIMUM TEMPERATURE-
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

■	Station Location

Lowest Minimum Temperature (°C)

—	Index Isoline (1.0°C)

Boundaries

⬚	Block
▨	District
🟩	Agroclimatic Zones
⬚	State

Labels

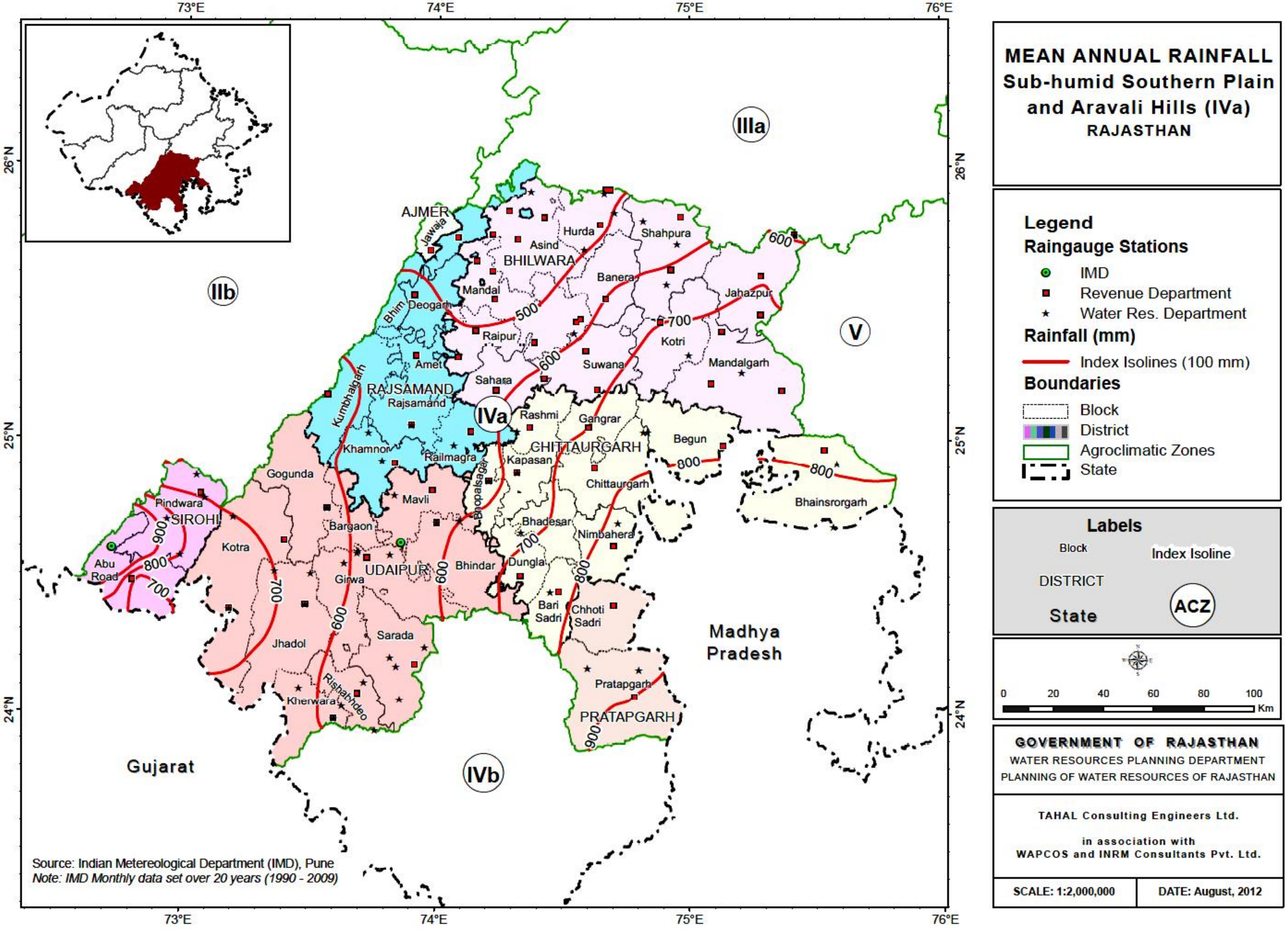
Station Name (Mean Value) Block
Index Isoline DISTRICT
ACZ State

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000
DATE: August, 2012



MEAN ANNUAL RAINFALL
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

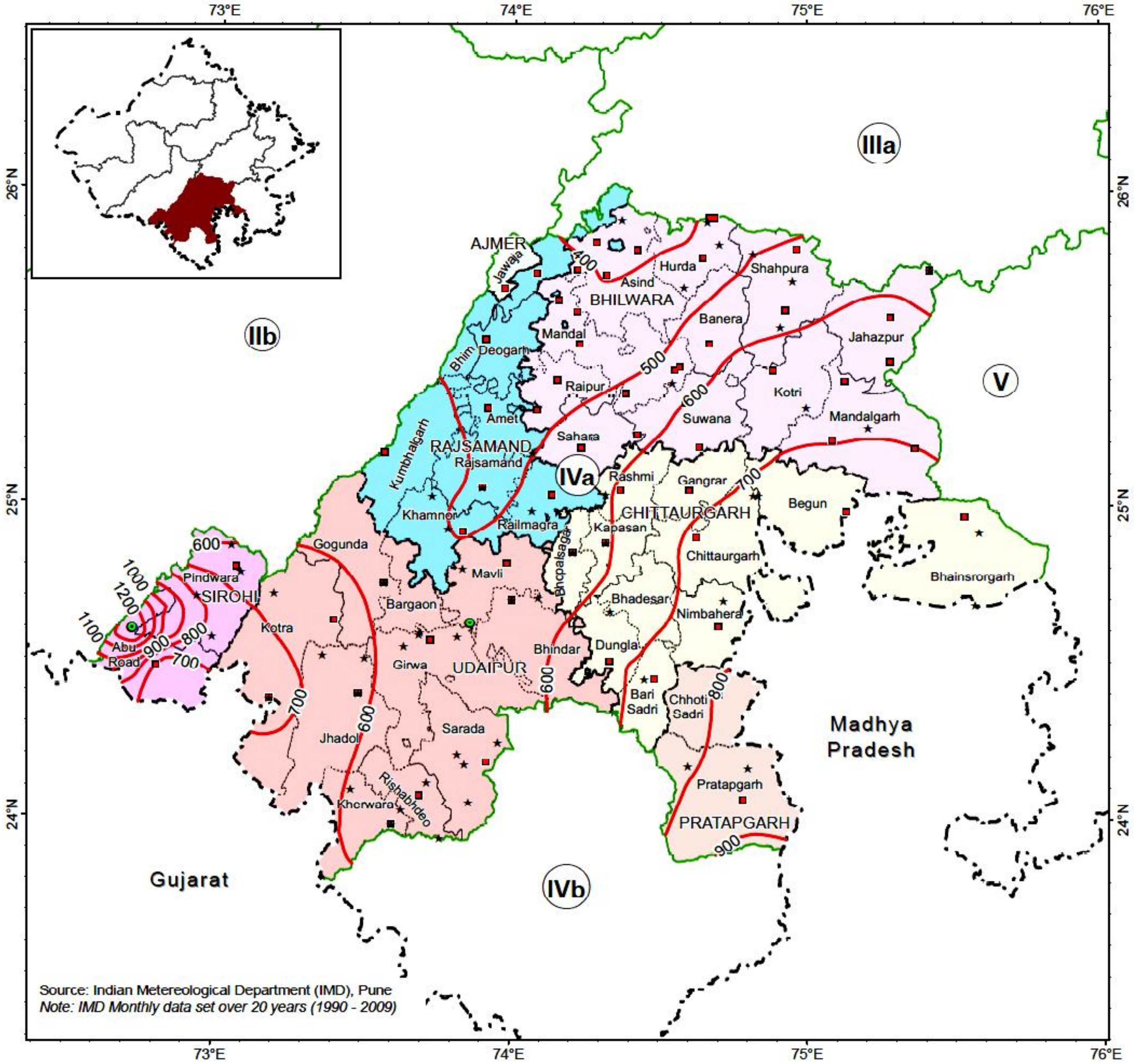
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000 | DATE: August, 2012



MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)

- — Index Isolines (100 mm)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

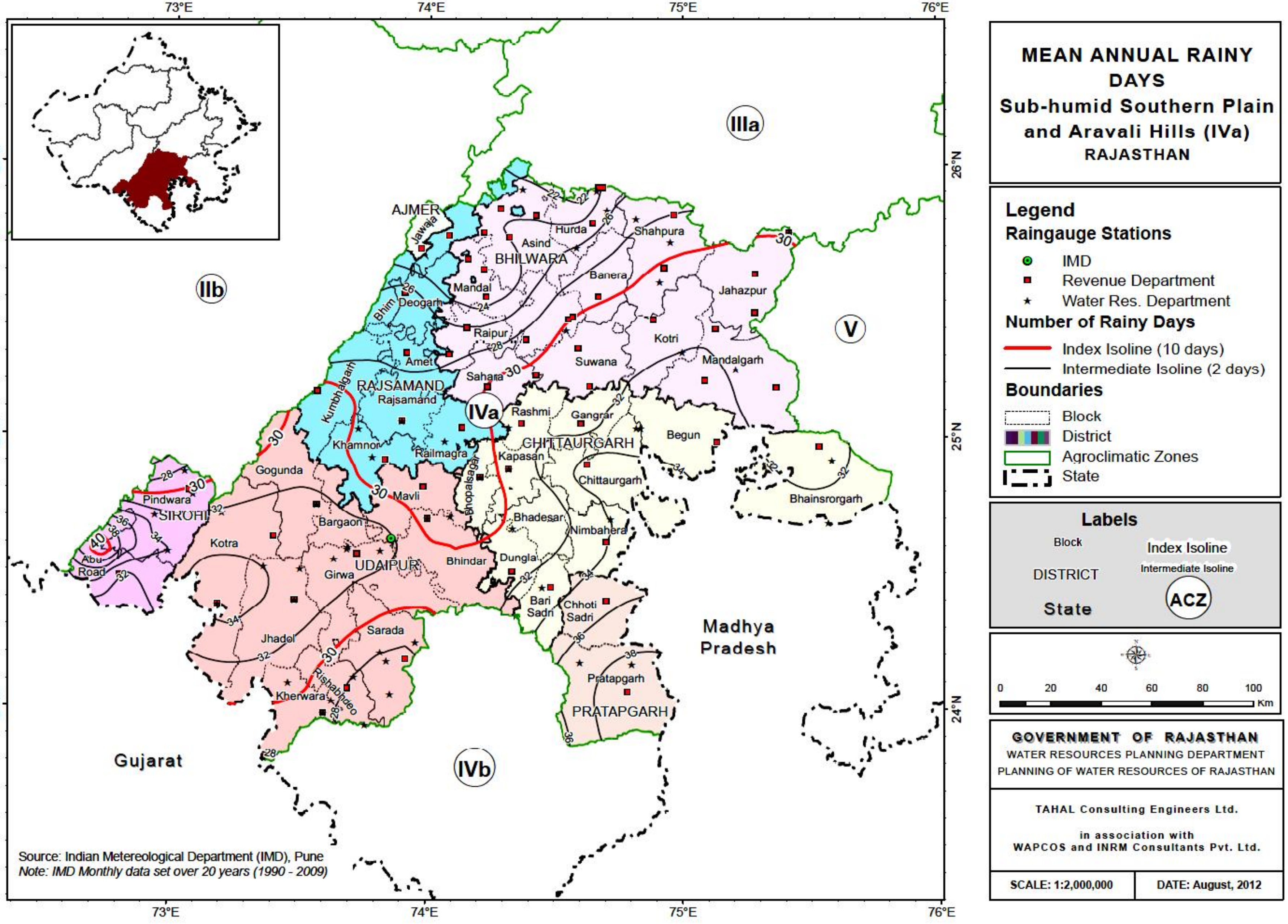
Block
Index Isoline
DISTRICT
State
ACZ

0 20 40 60 80 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000	DATE: August, 2012



MEAN ANNUAL RAINY DAYS
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Number of Rainy Days

- Index Isoline (10 days)
- Intermediate Isoline (2 days)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Block

DISTRICT

State

Index Isoline

Intermediate Isoline

ACZ

Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

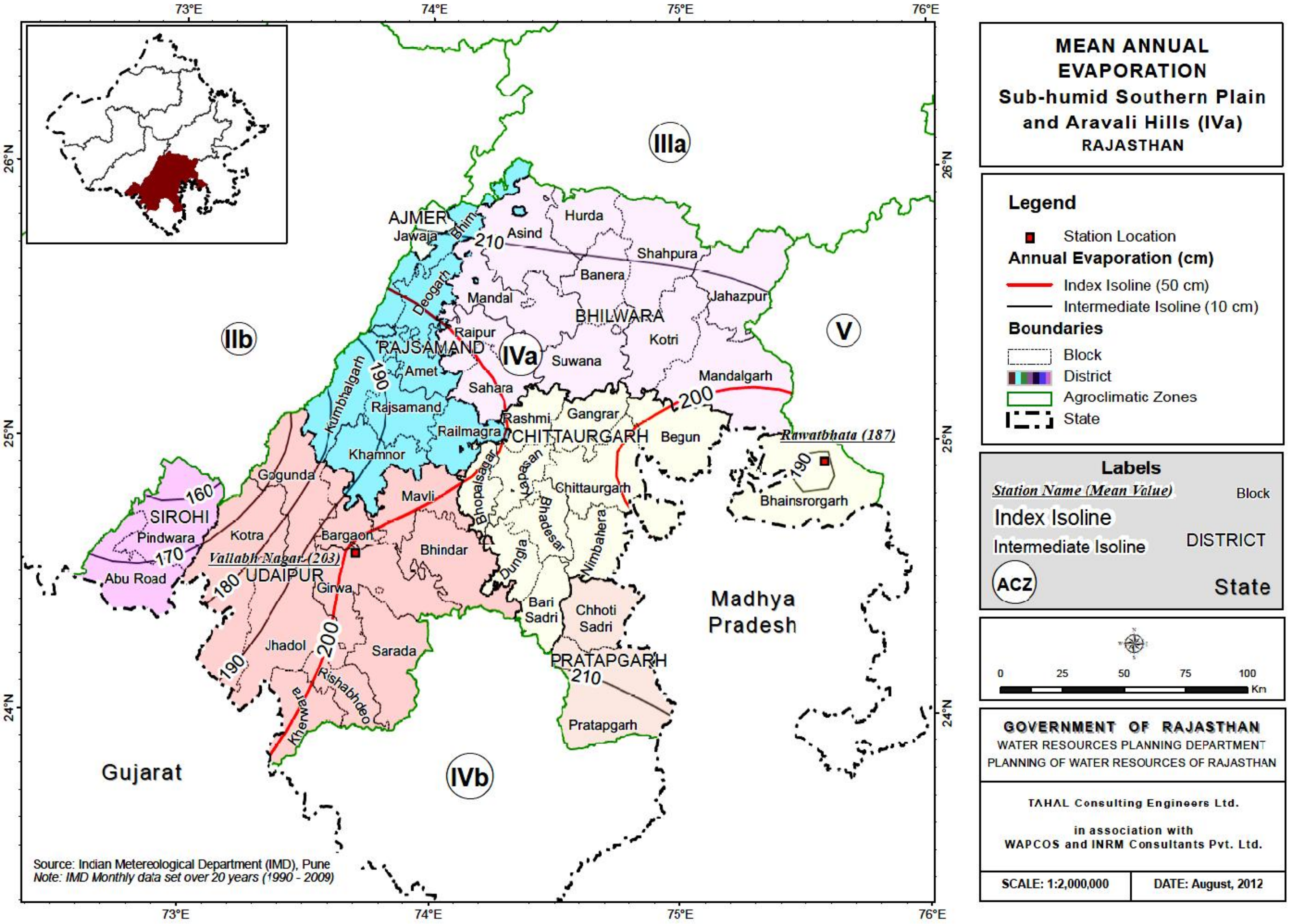
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000

DATE: August, 2012



MEAN ANNUAL EVAPORATION
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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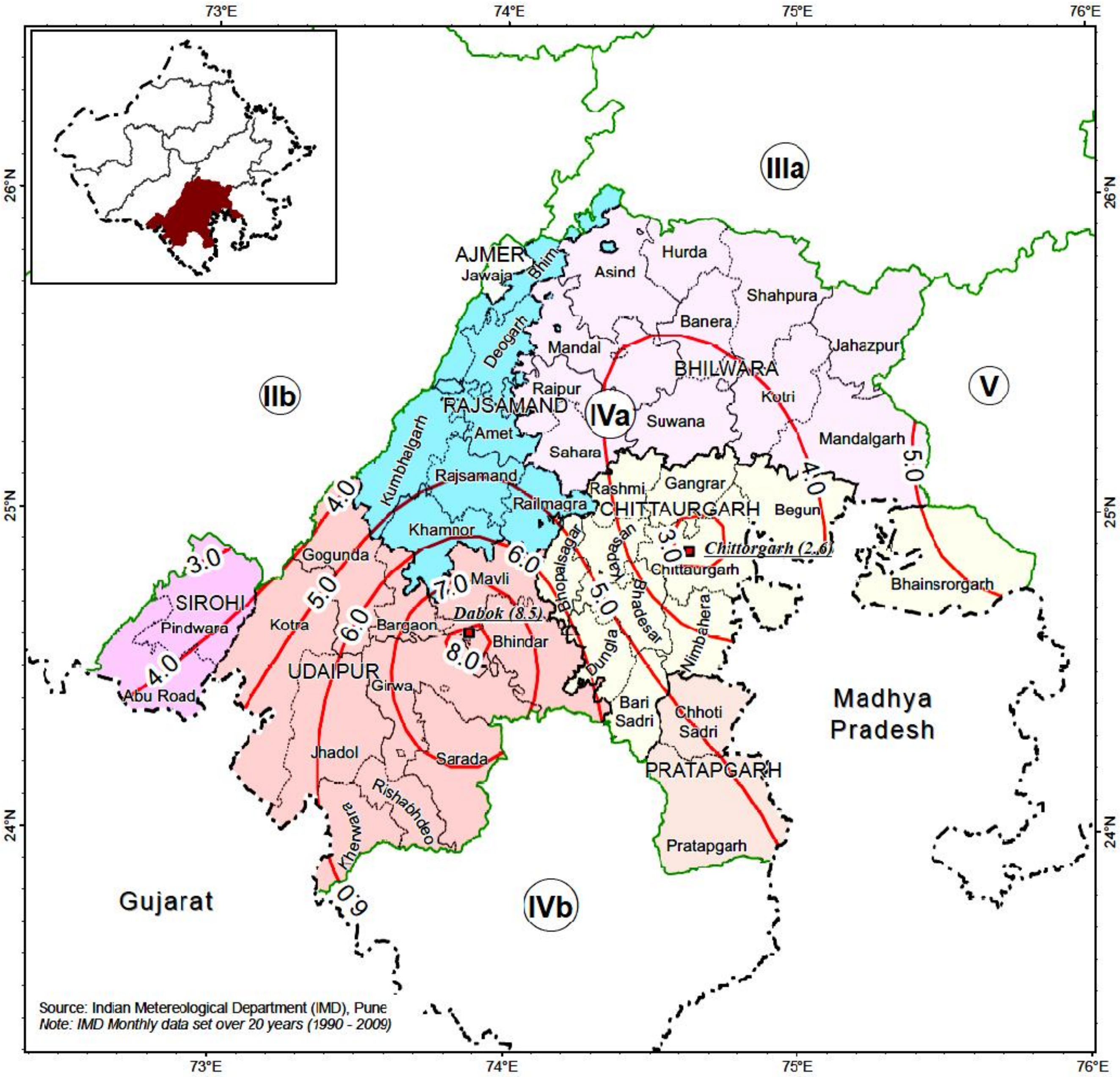
SCALE: 1:2,000,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

■ Station Location

Windspeed (km/h)

— Index Isoline (1 km/h)

Boundaries

⬚	Block
▨	District
▭	Agroclimatic Zones
⬚	State

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

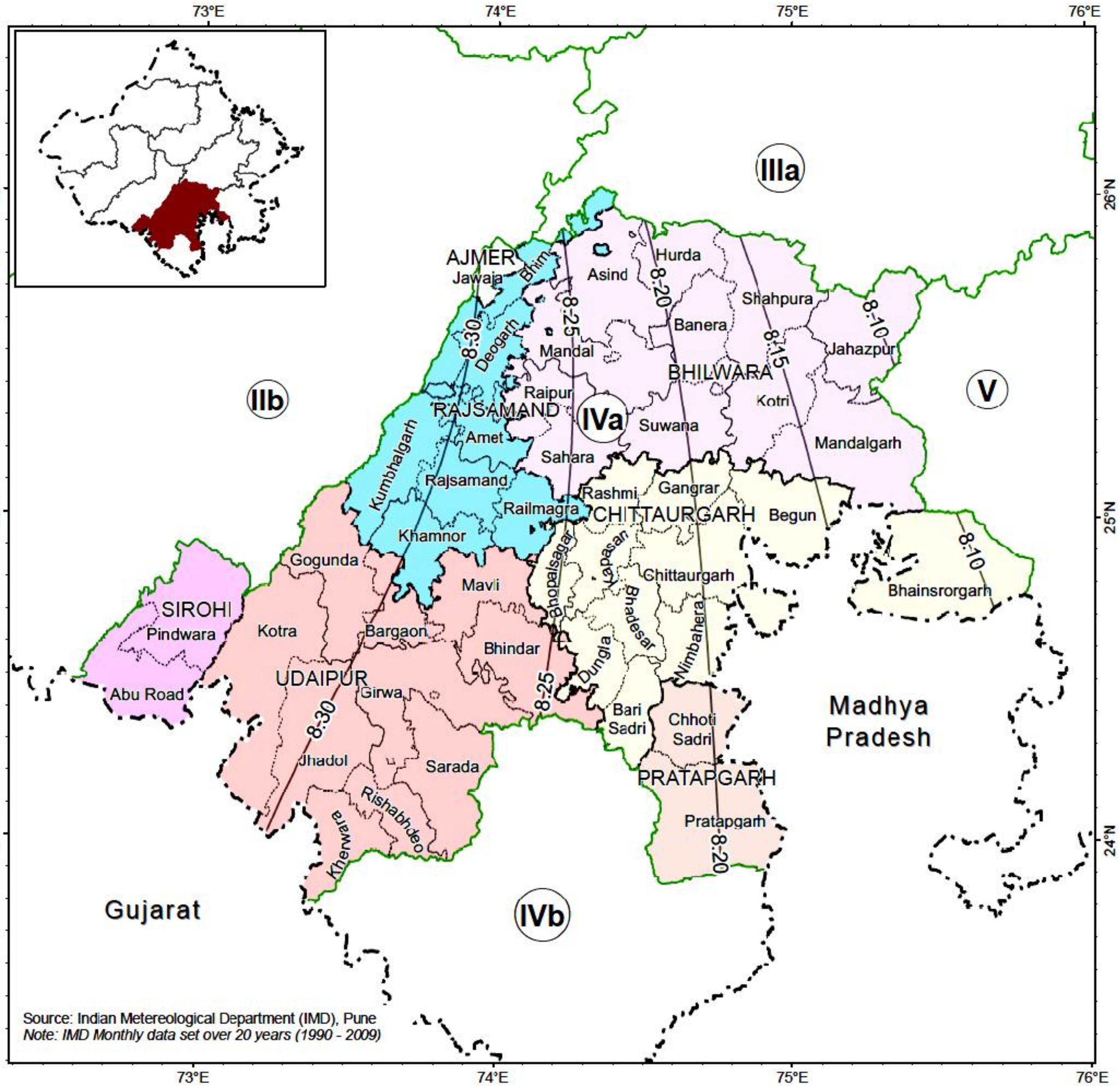
ACZ State

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY SUNSHINE HOURS
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

■ Station Location

Sunshine Hours

—	Index Isoline (30 minute)
—	Intermediate Isoline (3 minute)

Boundaries

☐	Block
▨	District
☐	Agroclimatic Zones
☐	State

Labels

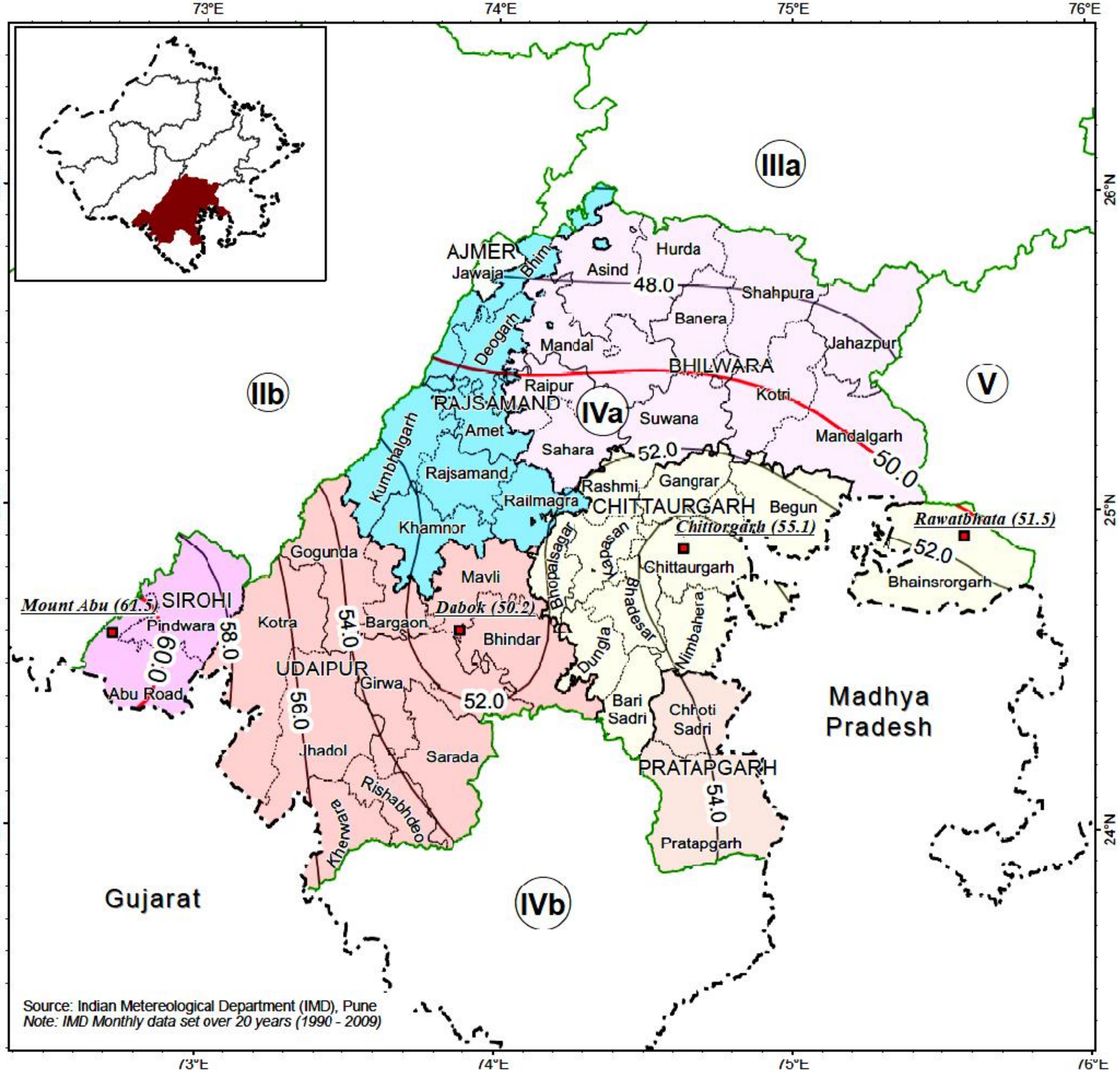
Station Name (Mean Value) Block
Index Isoline
Intermediate Isoline DISTRICT
ACZ State

0 25 50 75 100 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000 DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY RELATIVE HUMIDITY
Sub-humid Southern Plain and Aravali Hills (IVa)
RAJASTHAN

Legend

■ Station Location

Relative Humidity (%)

▬	Index Isoline (10%)
—	Intermediate Isoline (2%)

Boundaries

┄	Block
▨	District
🟩	Agroclimatic Zones
▭	State

Labels

Station Name (Mean Value) Block

Index Isoline

Intermediate Isoline DISTRICT

ACZ State

0 25 50 75 100 Km

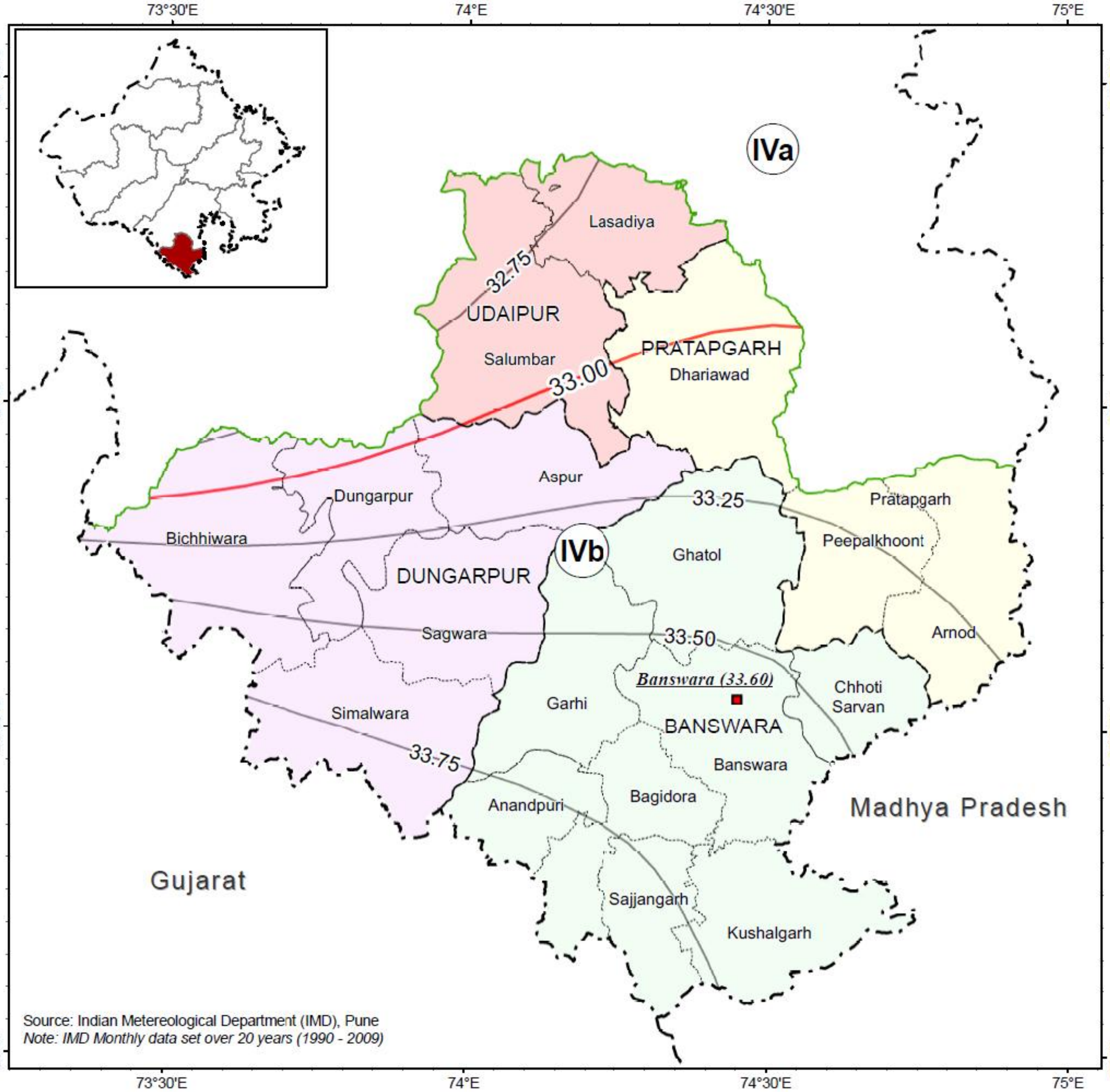
GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:2,000,000	DATE: August, 2012

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Humid Southern Plain (IVb)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

■ Station Location

Maximum Temperature (°C)

- Index Isoline (1.0°C)
- Intermediate Isoline (0.25°)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Station Name (Mean Value)
Block
Index Isoline
DISTRICT
Intermediate Isoline
State
ACZ

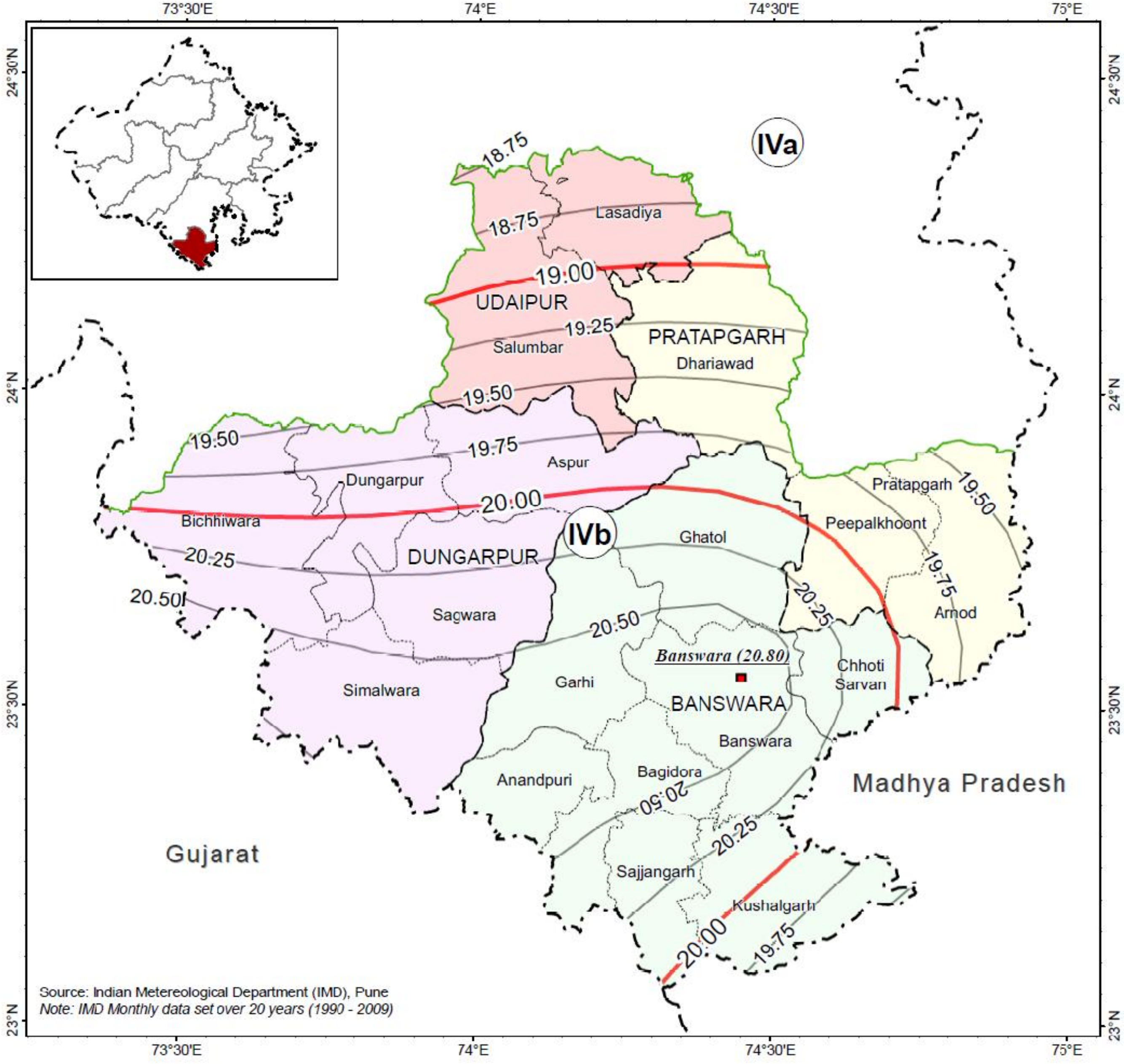
0 10 20 30 40 50 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
In association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000 **DATE: August, 2012**

MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Humid Southern Plain (IVb)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

🟥 Station Location

Minimum Temperature (°C)

━	Index Isoline (1.0°C)
─	Intermediate Isoline (0.5°C)

Boundaries

┅	Block
▨	District
☐	Agroclimatic Zones
┅	State

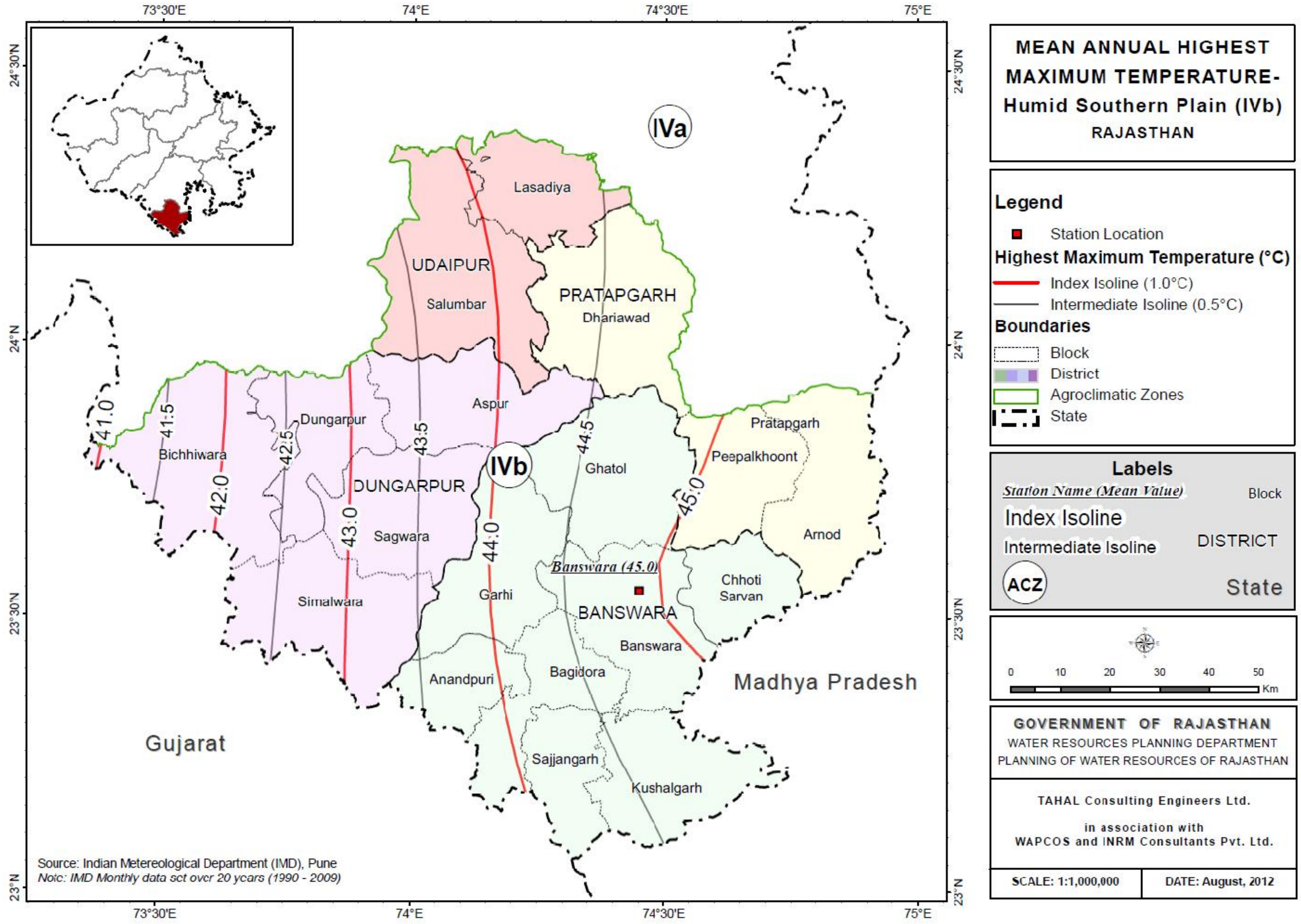
Labels

Station Name (Mean Value)	Block
Index Isoline	
Intermediate Isoline	DISTRICT
ACZ	State

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000	DATE: August, 2012



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Humid Southern Plain (IVb)

RAJASTHAN

Source: Indian Metereological Department (IMD), Pune

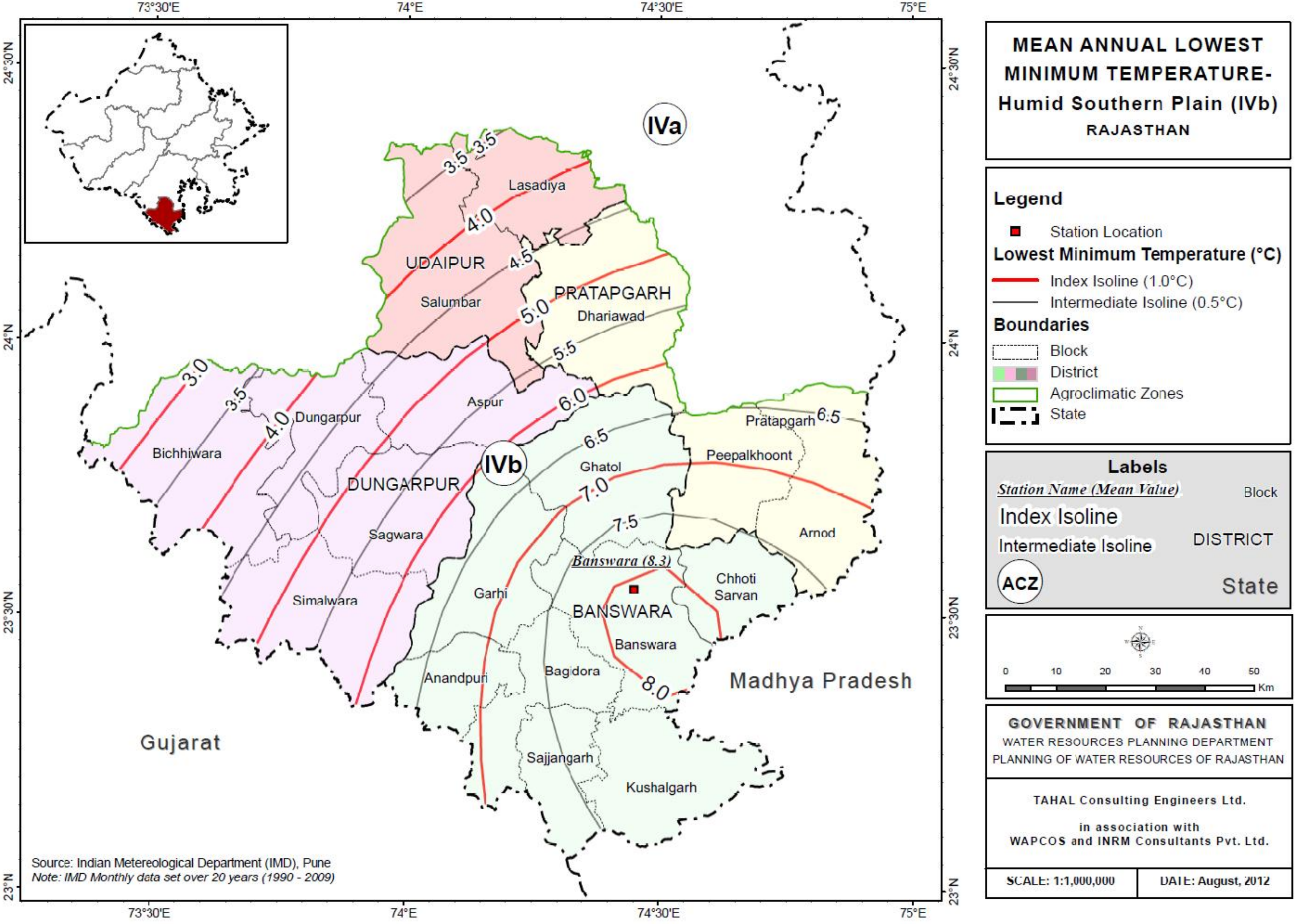
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL LOWEST MINIMUM TEMPERATURE-
Humid Southern Plain (IVb)
RAJASTHAN

Legend

■ Station Location

Lowest Minimum Temperature (°C)

- Index Isoline (1.0°C)
- Intermediate Isoline (0.5°C)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

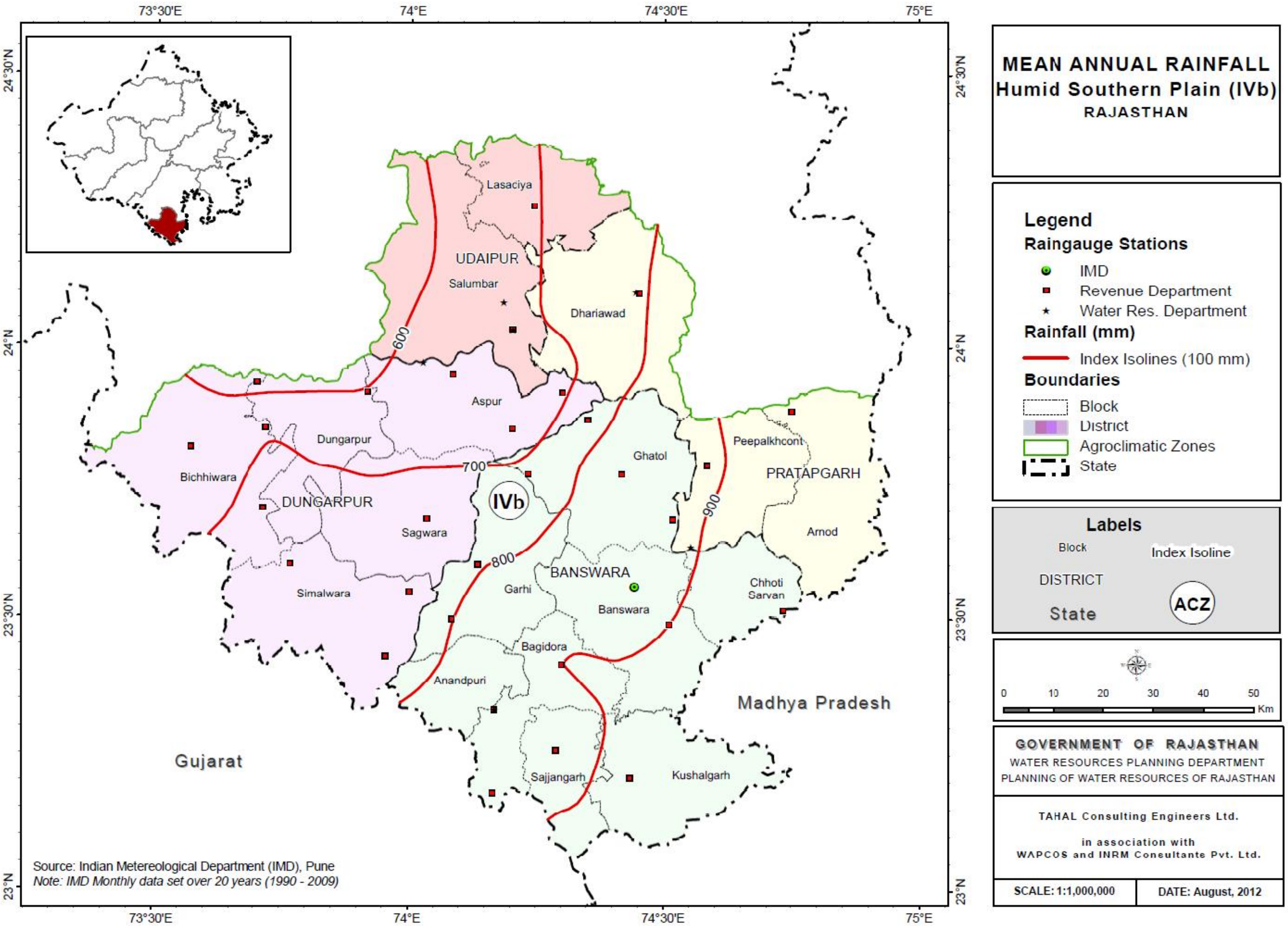
Station Name (Mean Value) Block
Index Isoline
Intermediate Isoline DISTRICT
ACZ State

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

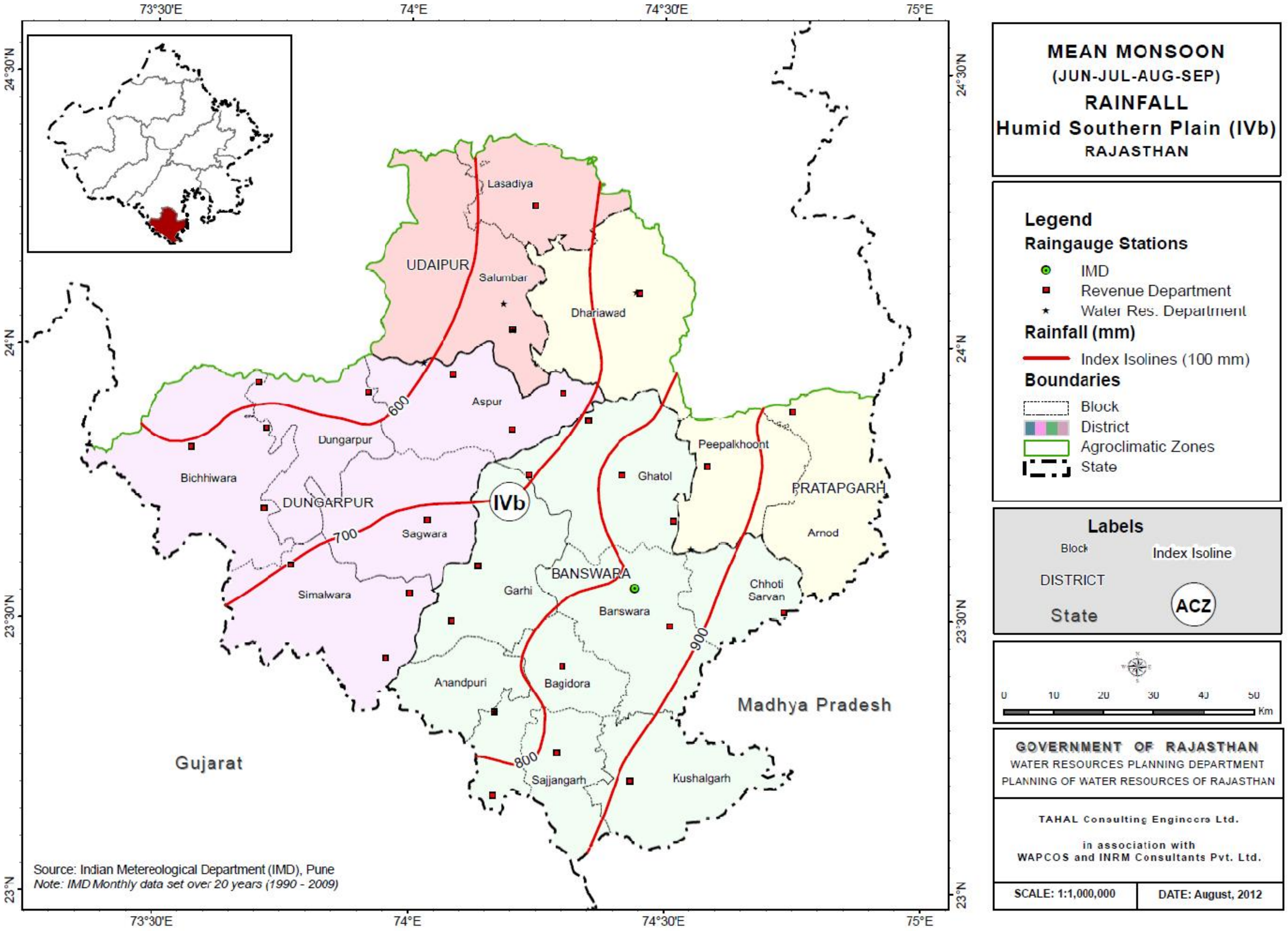
TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

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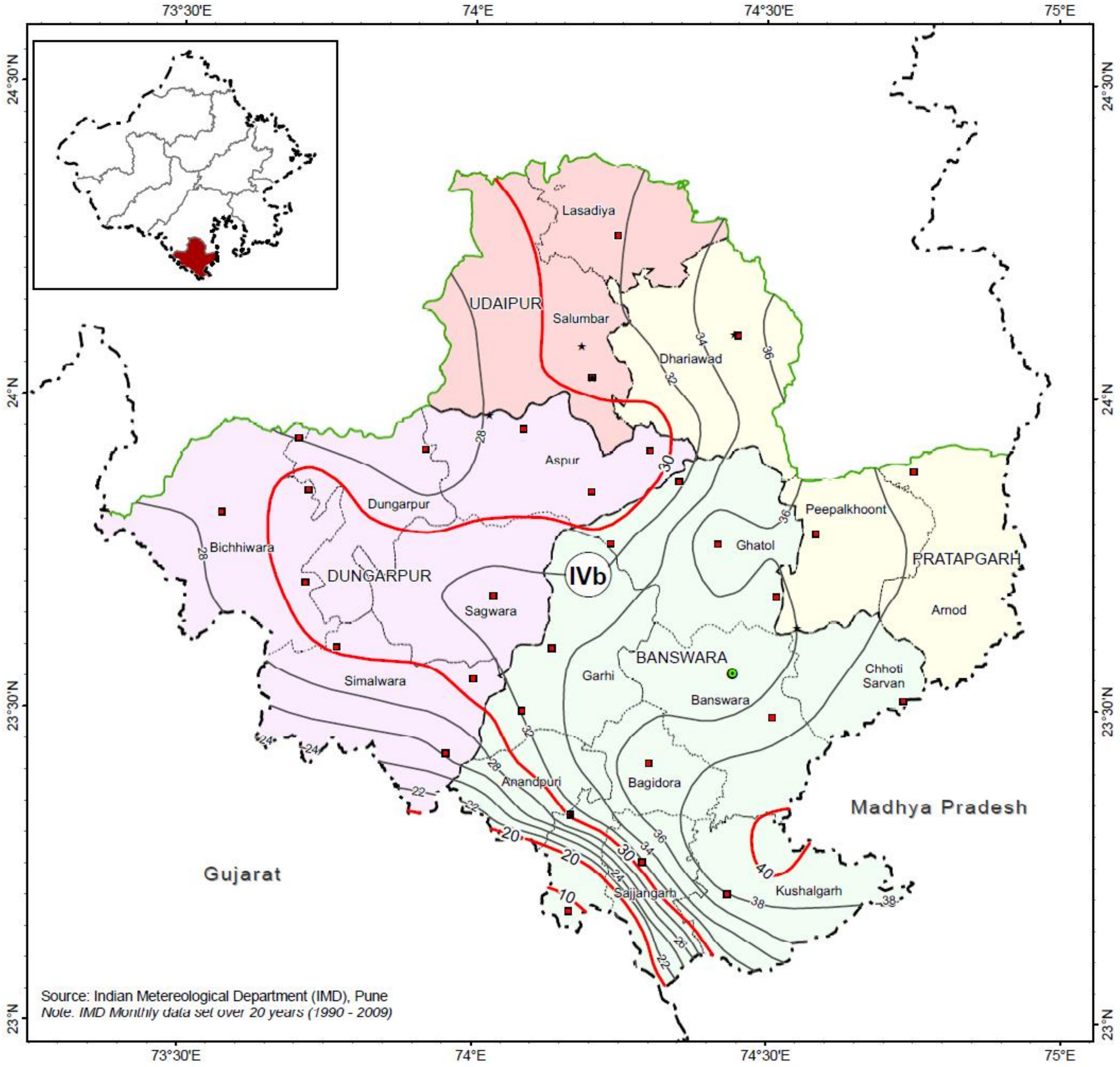


Source: Indian Metereological Department (IMD), Pune

Note. IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL RAINY DAYS
Humid Southern Plain (IVb)
RAJASTHAN

Legend

Raingauge Stations

⊙	IMD
■	Revenue Department
★	Water Res. Department

Number of Rainy Days

—	Index Isoline (10 days)
—	Intermediate Isoline (2 days)

Boundaries

⬚	Block
▨	District
▭	Agroclimatic Zones
⌐	State

Labels

Block

Index Isoline

DISTRICT

Intermediate Isoline

State

ACZ

0 10 20 30 40 50 Km

GOVERNMENT OF RAJASTHAN

WATER RESOURCES PLANNING DEPARTMENT

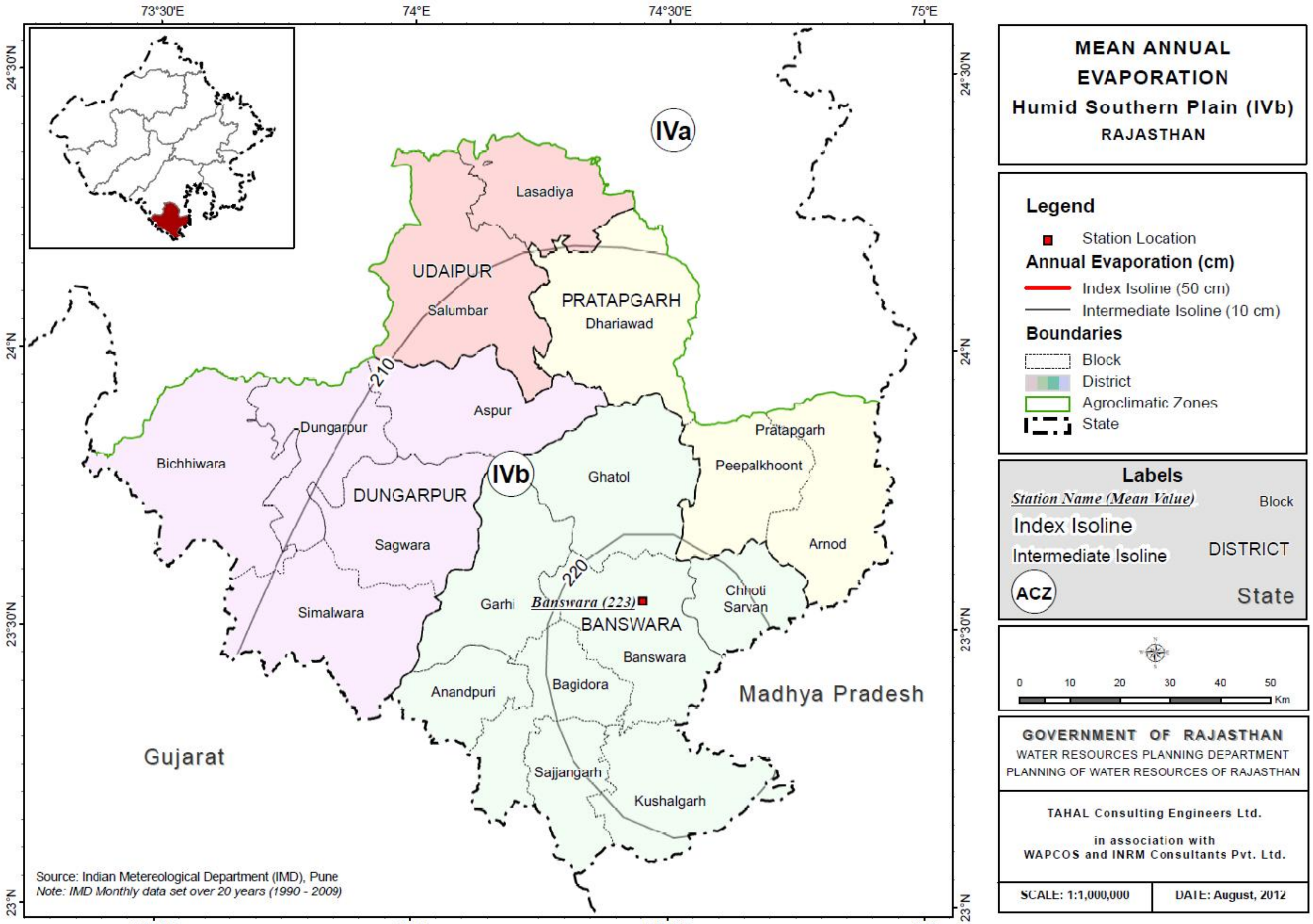
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with

WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000	DATE: August, 2012



MEAN ANNUAL EVAPORATION
Humid Southern Plain (IVb)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
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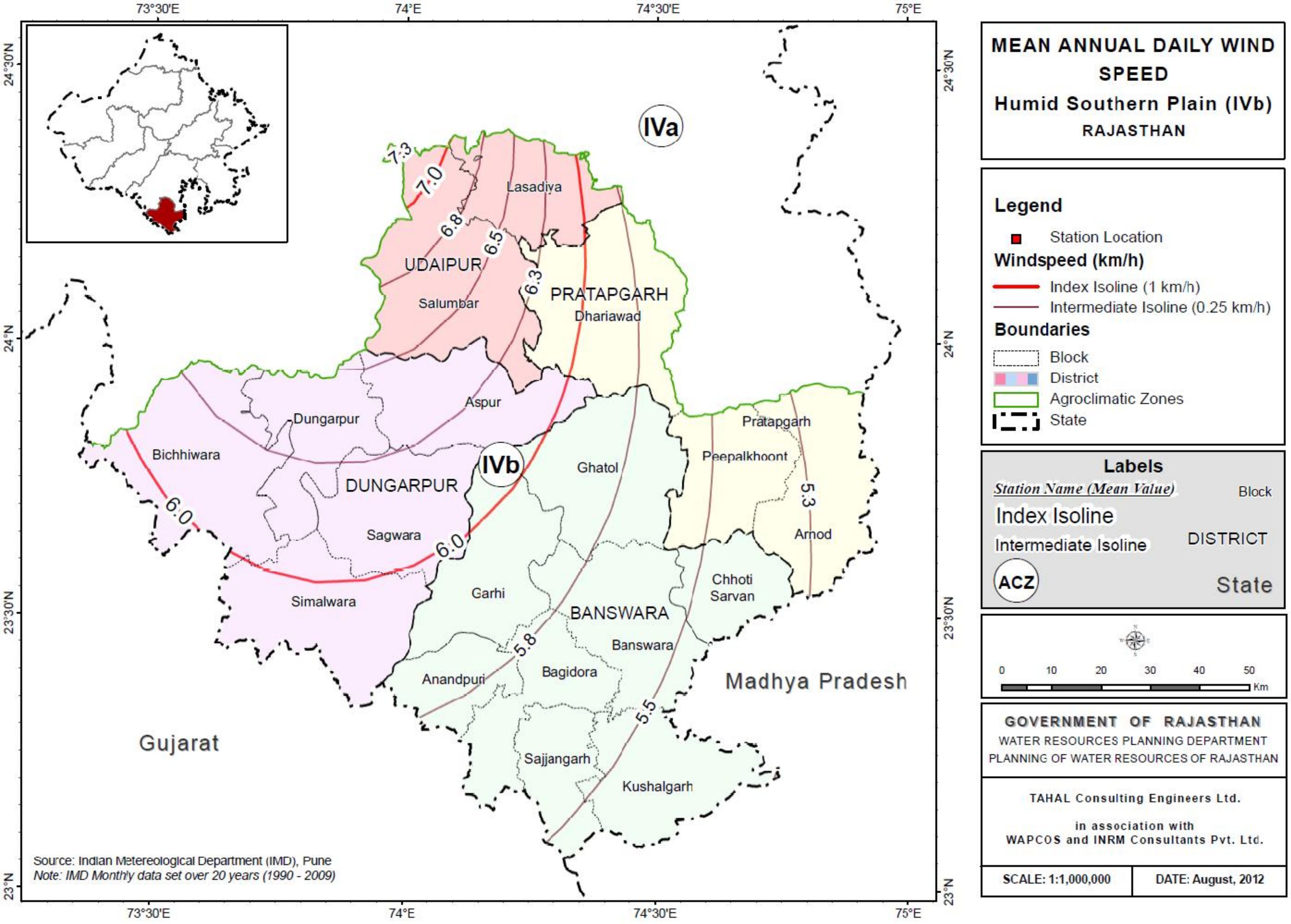
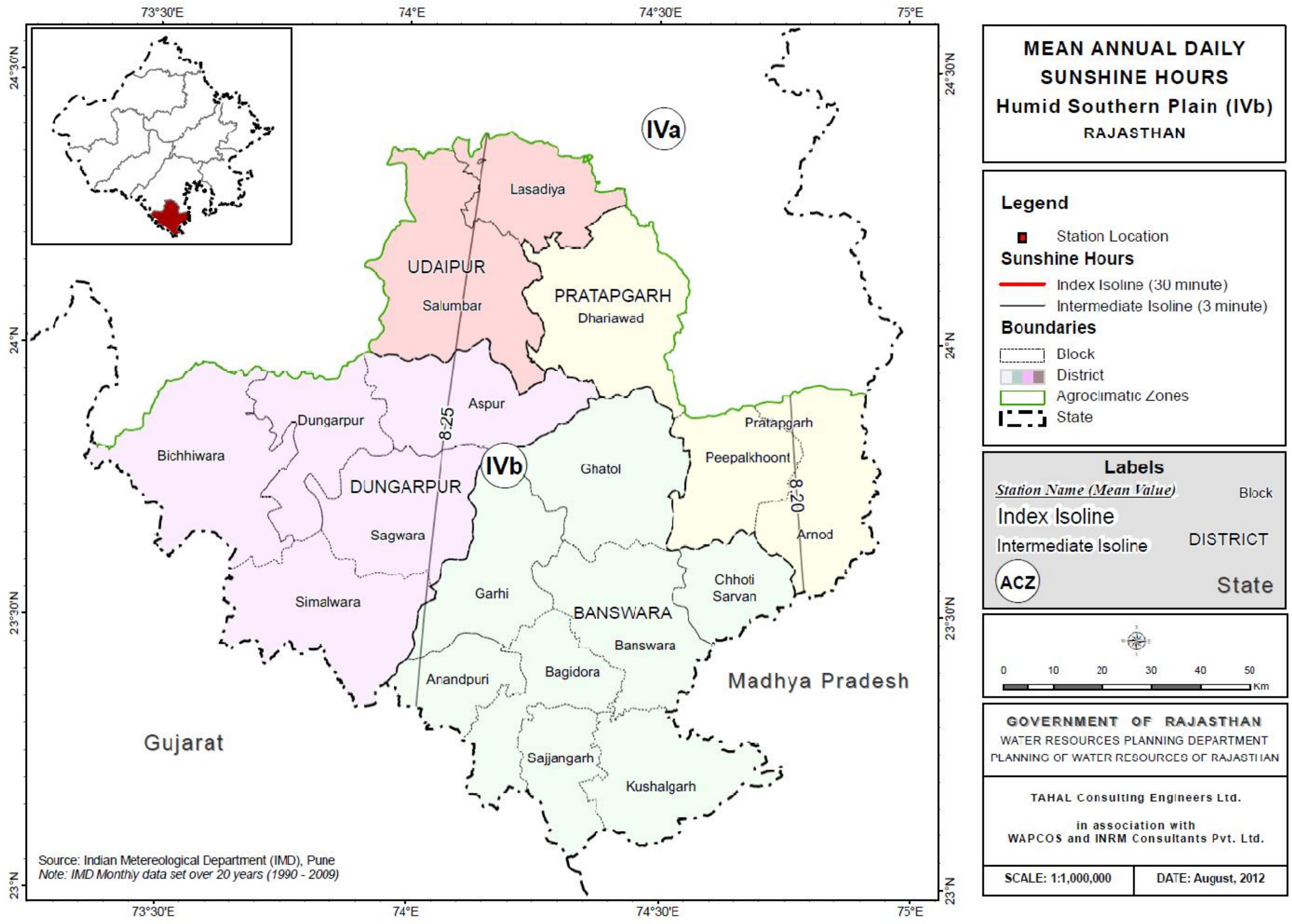
SCALE: 1:1,000,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL DAILY SUNSHINE HOURS

Humid Southern Plain (IVb)

RAJASTHAN

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
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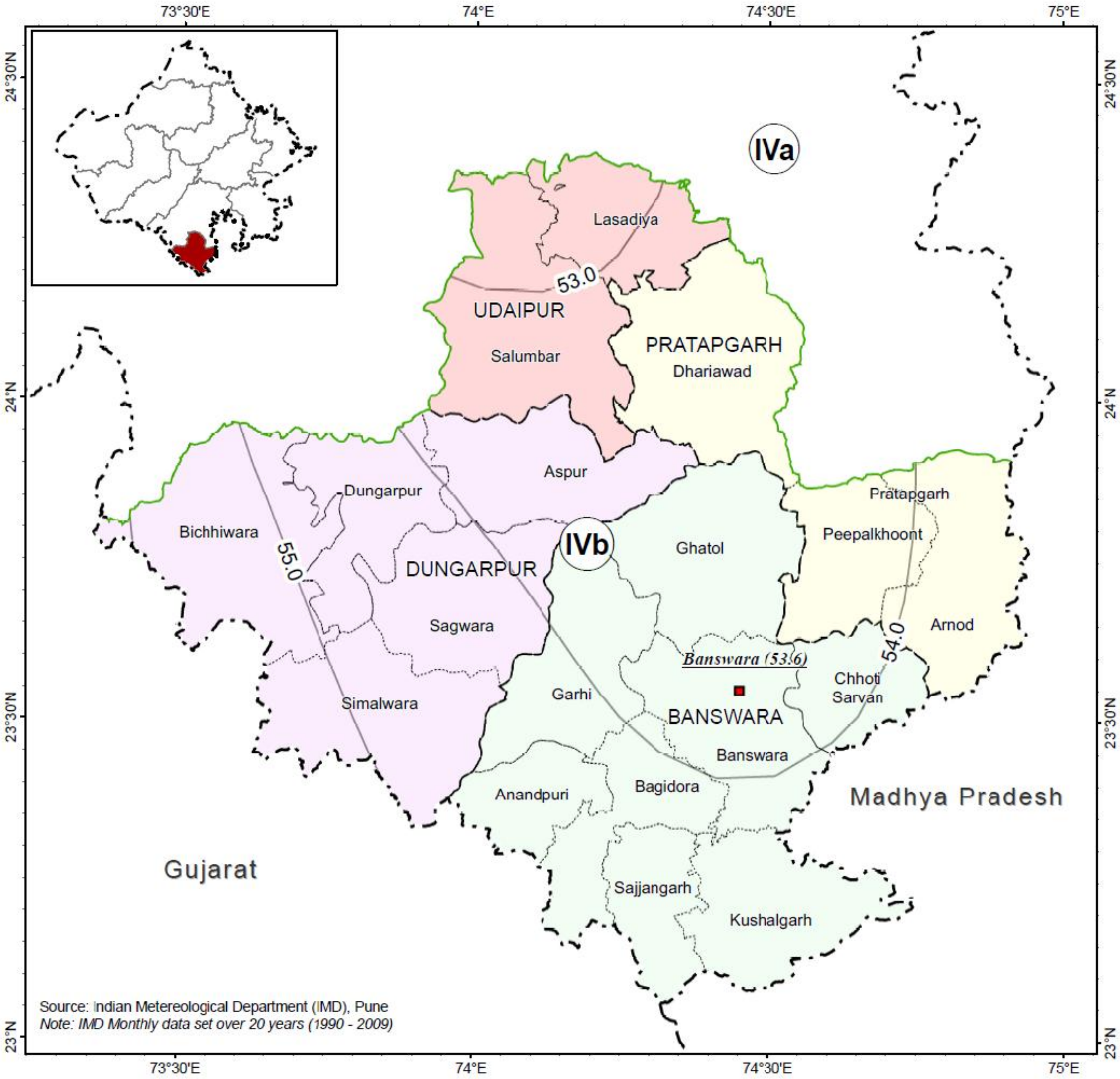
SCALE: 1:1,000,000

DATE: August, 2012

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY RELATIVE HUMIDITY
Humid Southern Plain (IVb)
RAJASTHAN

Legend

🟥 Station Location

Relative Humidity (%)

Index Isoline (10%)

Intermediate Isoline (1%)

Boundaries

Block

District

Agroclimatic Zones

State

Labels

Station Name (Mean Value) — Block

Index Isoline — DISTRICT

Intermediate Isoline

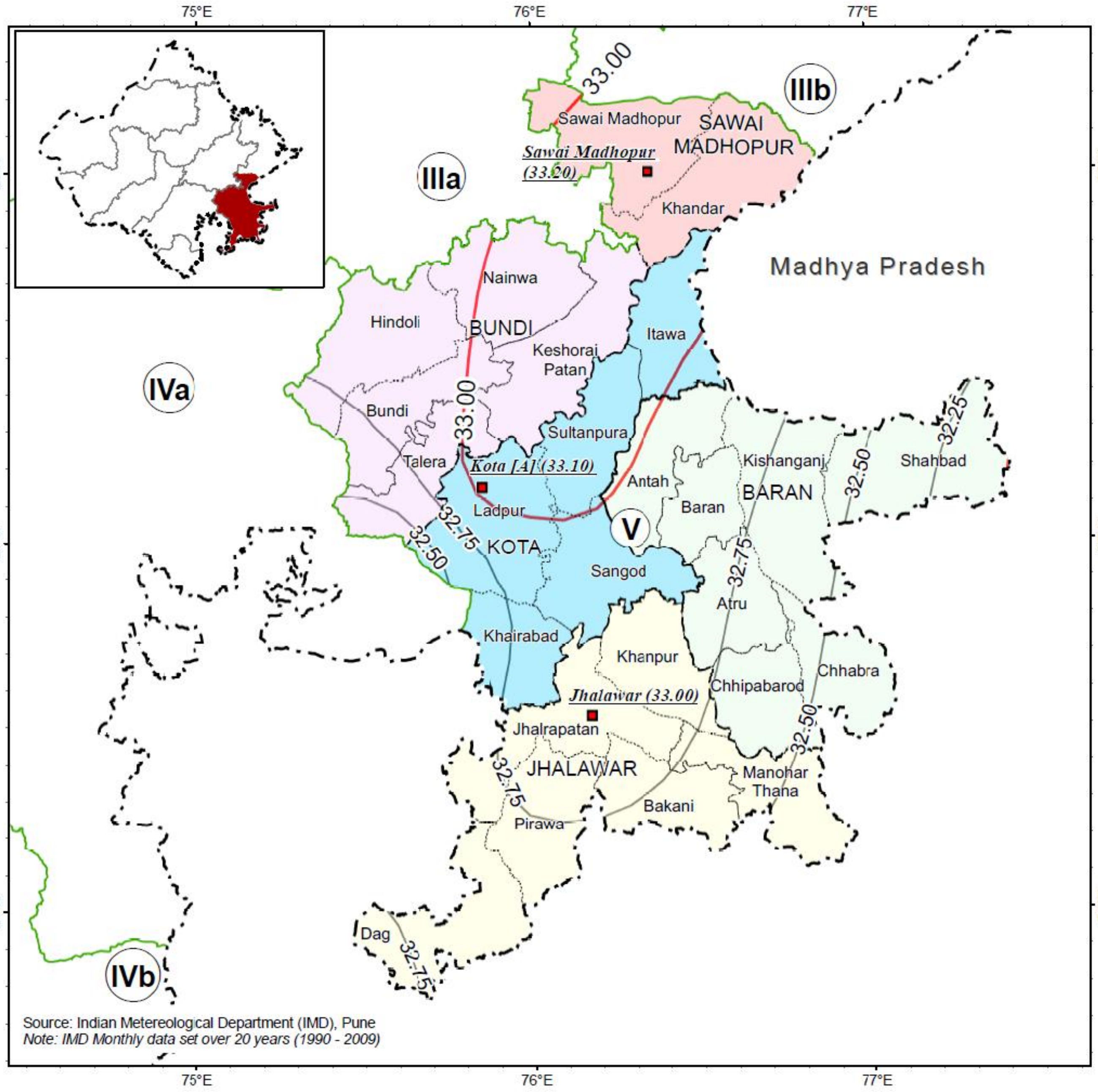
ACZ — State

0 10 20 30 40 50 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,000,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY MAXIMUM TEMPERATURE
Humid South-Eastern Plain (V)
RAJASTHAN

Legend

🟥	Station Location

Maximum Temperature (°C)

—	Index Isoline (1.0°C)
—	Intermediate Isoline (0.25°)

Boundaries

☐	Block
🟩	District
☐	Agroclimatic Zones
☐	State

Labels

Station Name (Mean Value) Block

Index Isoline DISTRICT

Intermediate Isoline

ACZ State

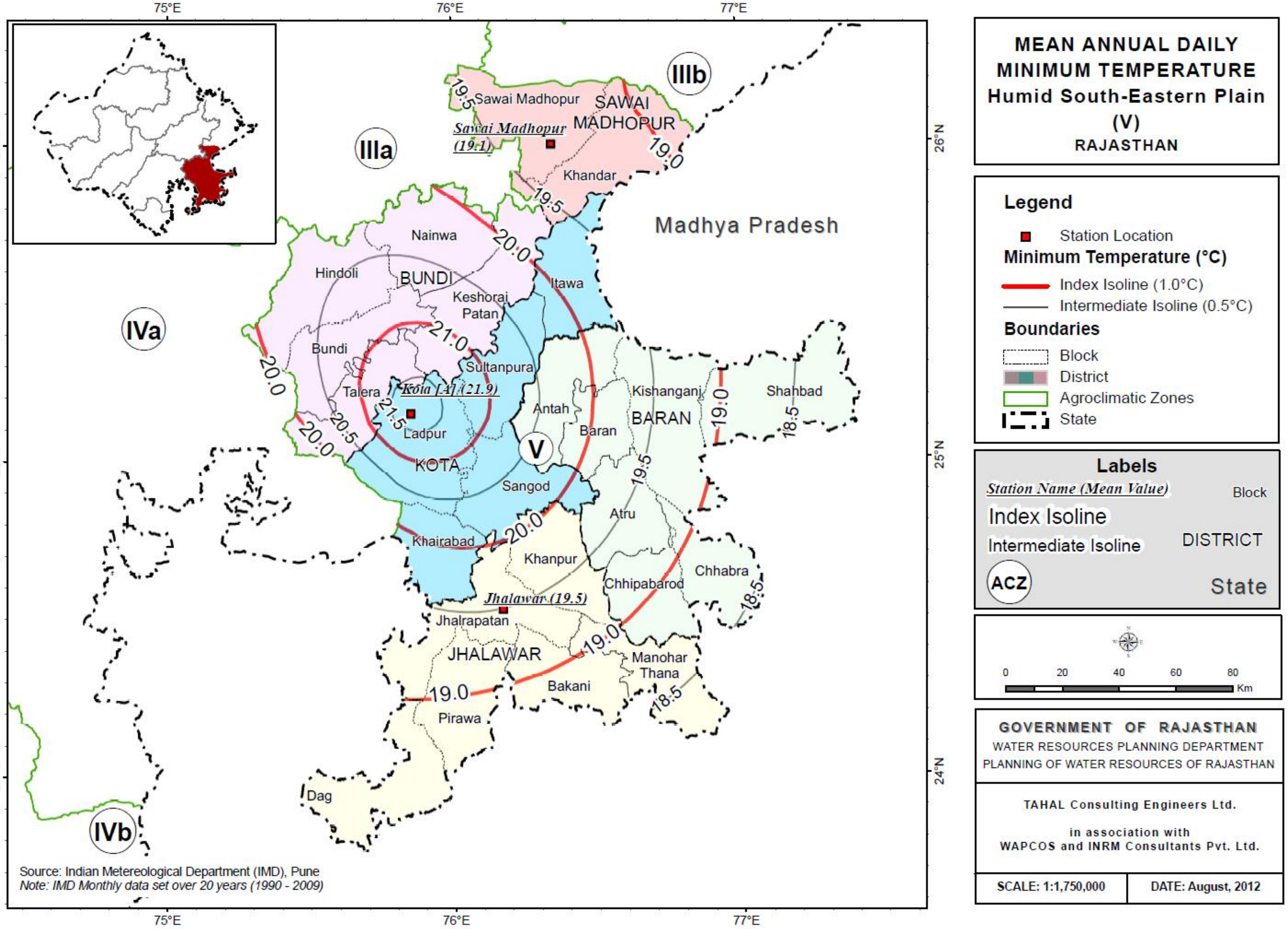
0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,750,000	DATE: August, 2012



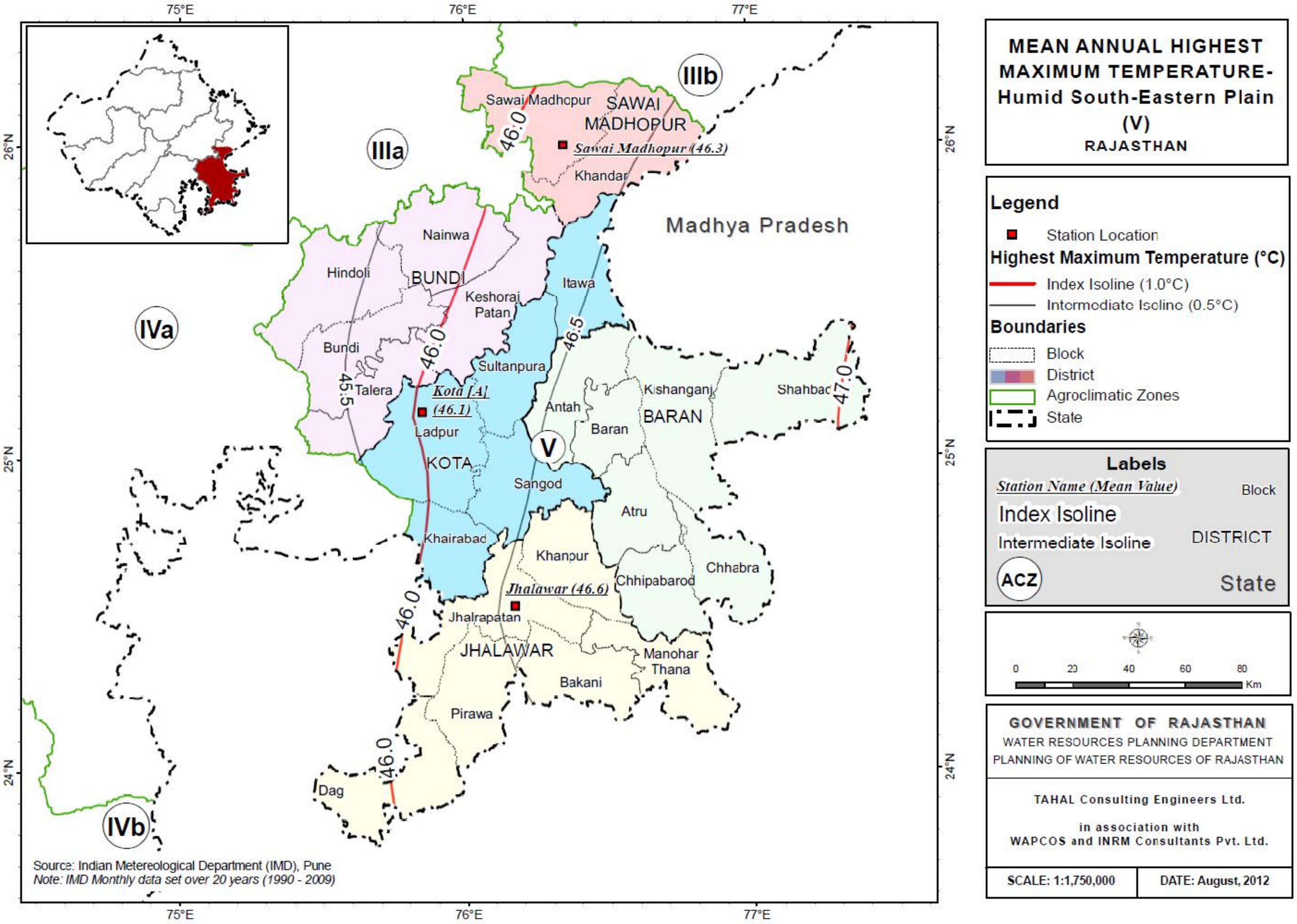
MEAN ANNUAL DAILY MINIMUM TEMPERATURE
Humid South-Eastern Plain (V)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.
in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,750,000
DATE: August, 2012



MEAN ANNUAL HIGHEST MAXIMUM TEMPERATURE- Humid South-Eastern Plain (V)

RAJASTHAN

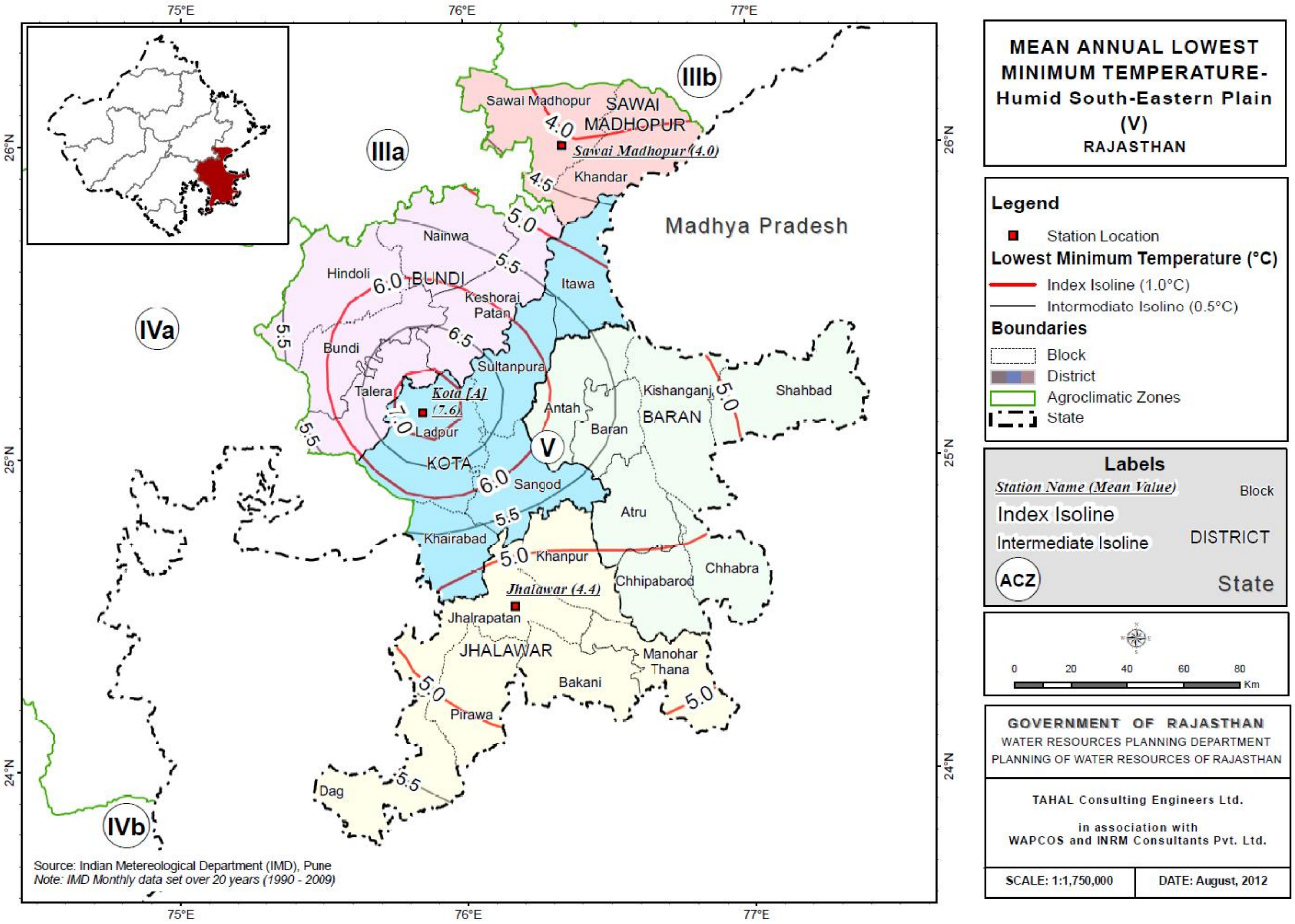
Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

in association with
WAPCOS and INRM Consultants Pvt. Ltd.

SCALE: 1:1,750,000	DATE: August, 2012



MEAN ANNUAL LOWEST MINIMUM TEMPERATURE-
Humid South-Eastern Plain
(V)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

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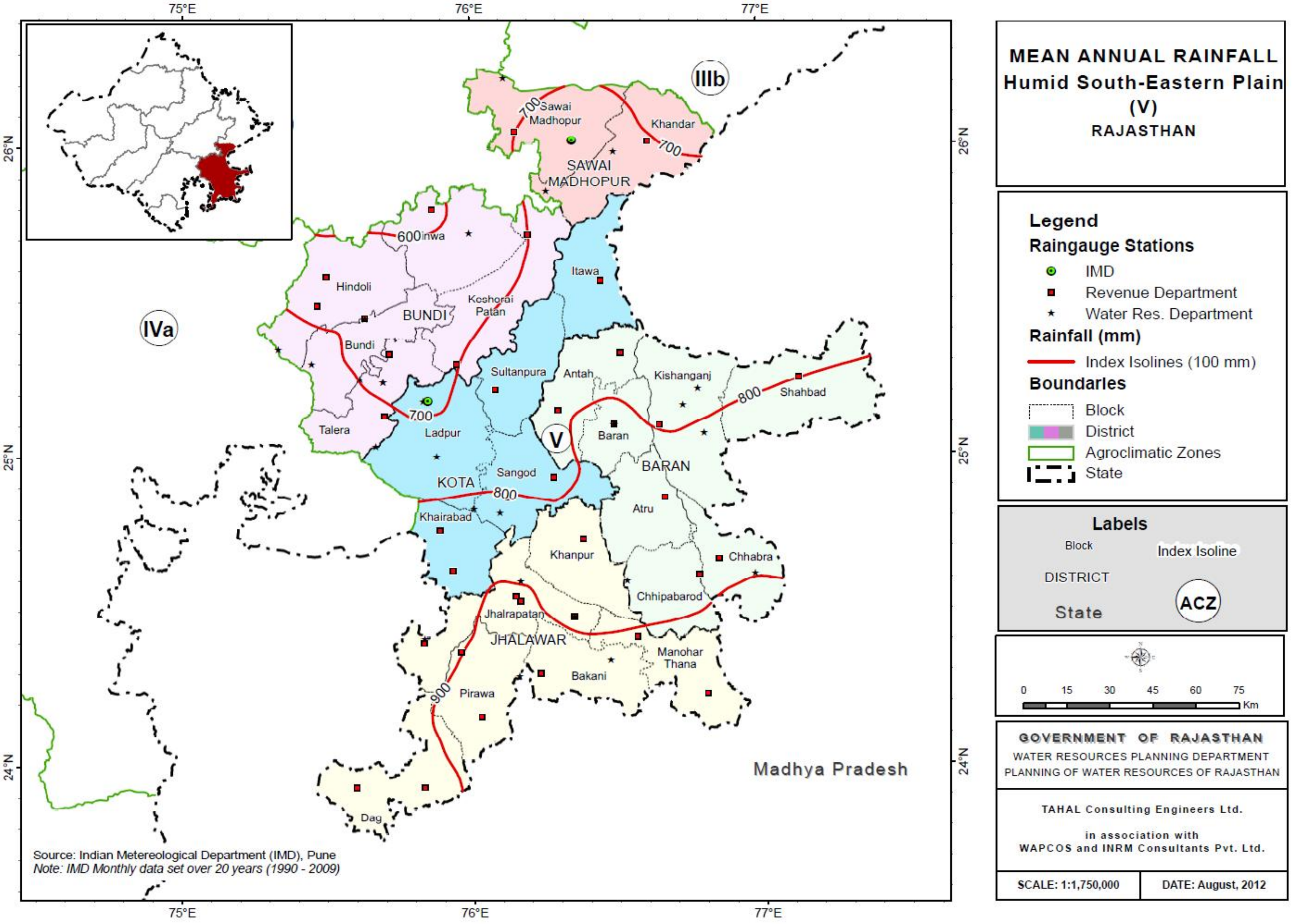
SCALE: 1:1,750,000
DATE: August, 2012



MEAN ANNUAL RAINFALL
Humid South-Eastern Plain
(V)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

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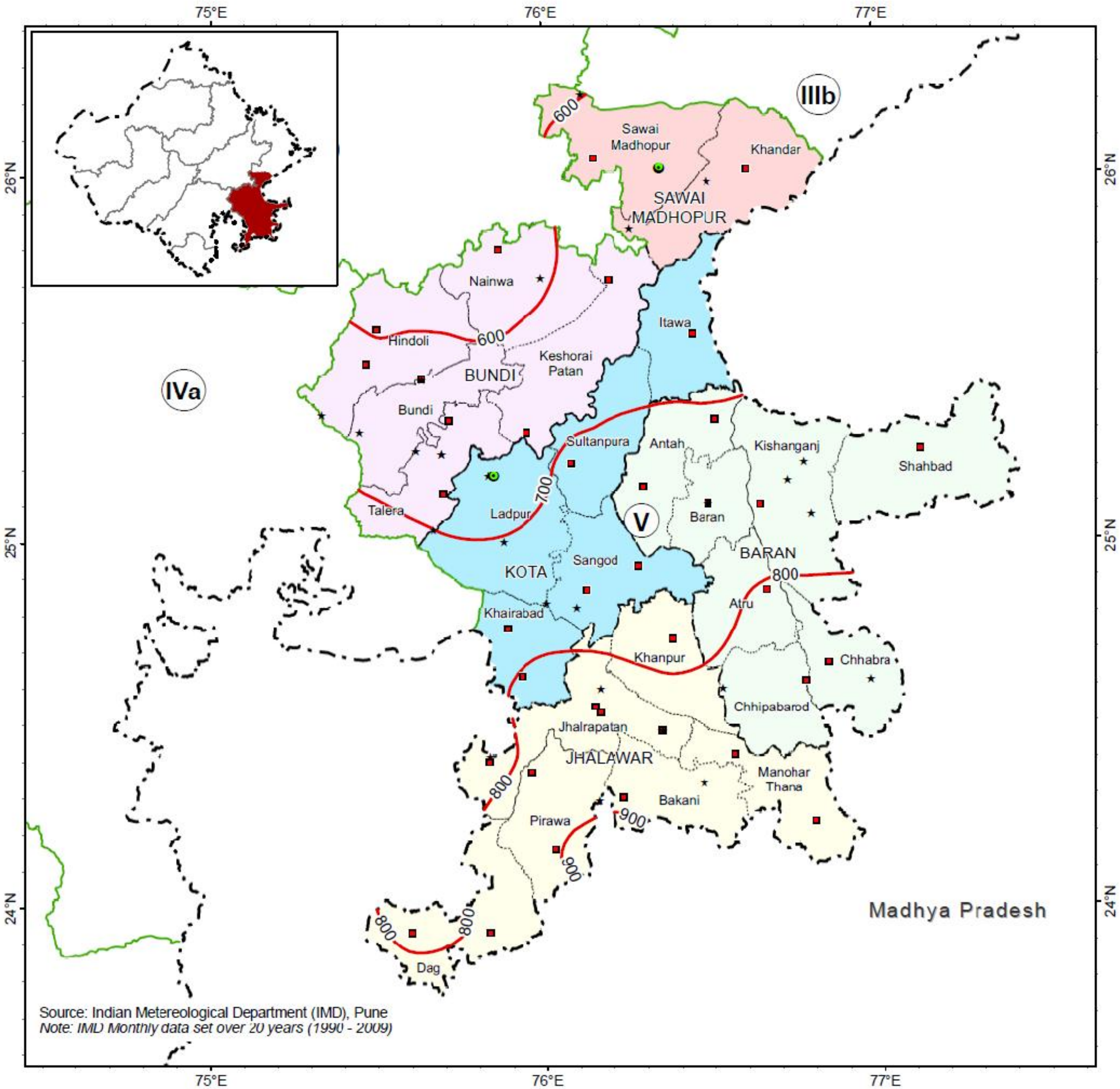
SCALE: 1:1,750,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN MONSOON
(JUN-JUL-AUG-SEP)
RAINFALL
Humid South-Eastern Plain
(V)
RAJASTHAN

Legend

Raingauge Stations
- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Rainfall (mm)
- — Index Isolines (100 mm)

Boundaries
- ⬚ Block
- ▭ District
- ▭ Agroclimatic Zones
- ▭ State

Labels

Block
Index Isoline
DISTRICT
State
ACZ

0 15 30 45 60 75 Km

GOVERNMENT OF RAJASTHAN
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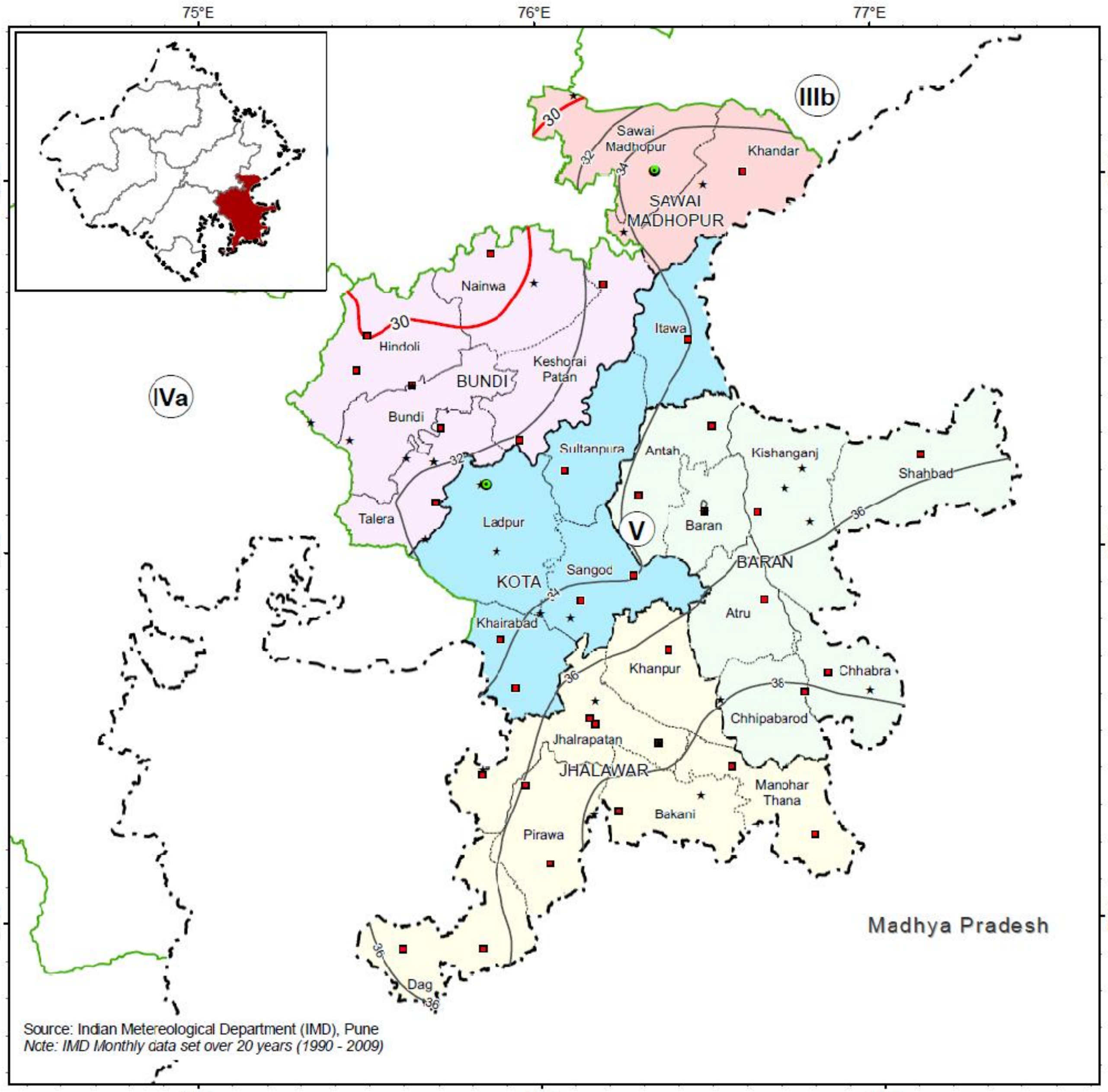
SCALE: 1:1,750,000	DATE: August, 2012

MEAN ANNUAL RAINY DAYS
Humid South-Eastern Plain (V)
RAJASTHAN



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

Legend

Raingauge Stations

- ● IMD
- ■ Revenue Department
- ★ Water Res. Department

Number of Rainy Days

- Index Isoline (10 days)
- Intermediate Isoline (2 days)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Block
DISTRICT
State
Index Isoline
Intermediate Isoline
ACZ

0 15 30 45 60 75 Km

GOVERNMENT OF RAJASTHAN
WATER RESOURCES PLANNING DEPARTMENT
PLANNING OF WATER RESOURCES OF RAJASTHAN

TAHAL Consulting Engineers Ltd.

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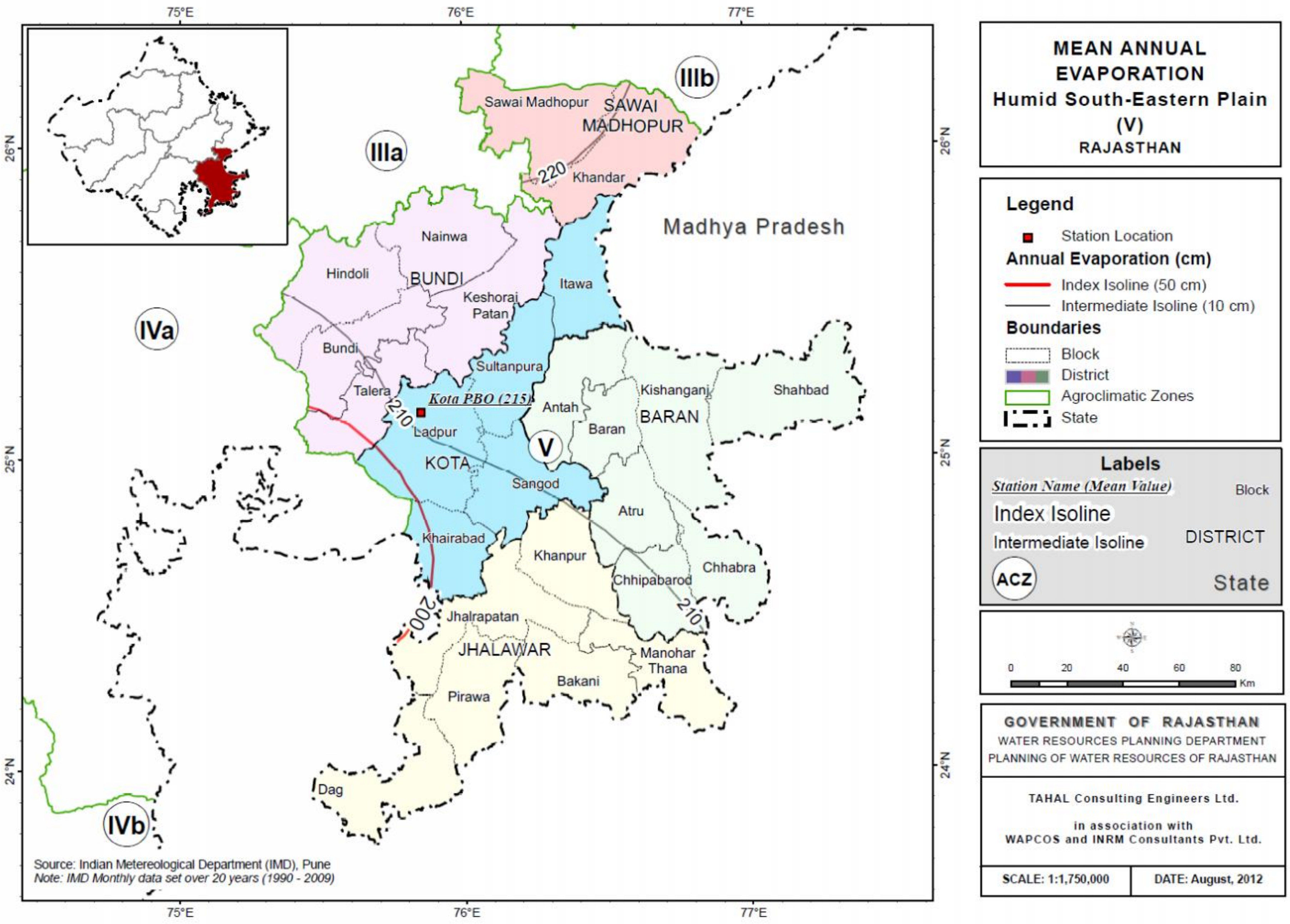
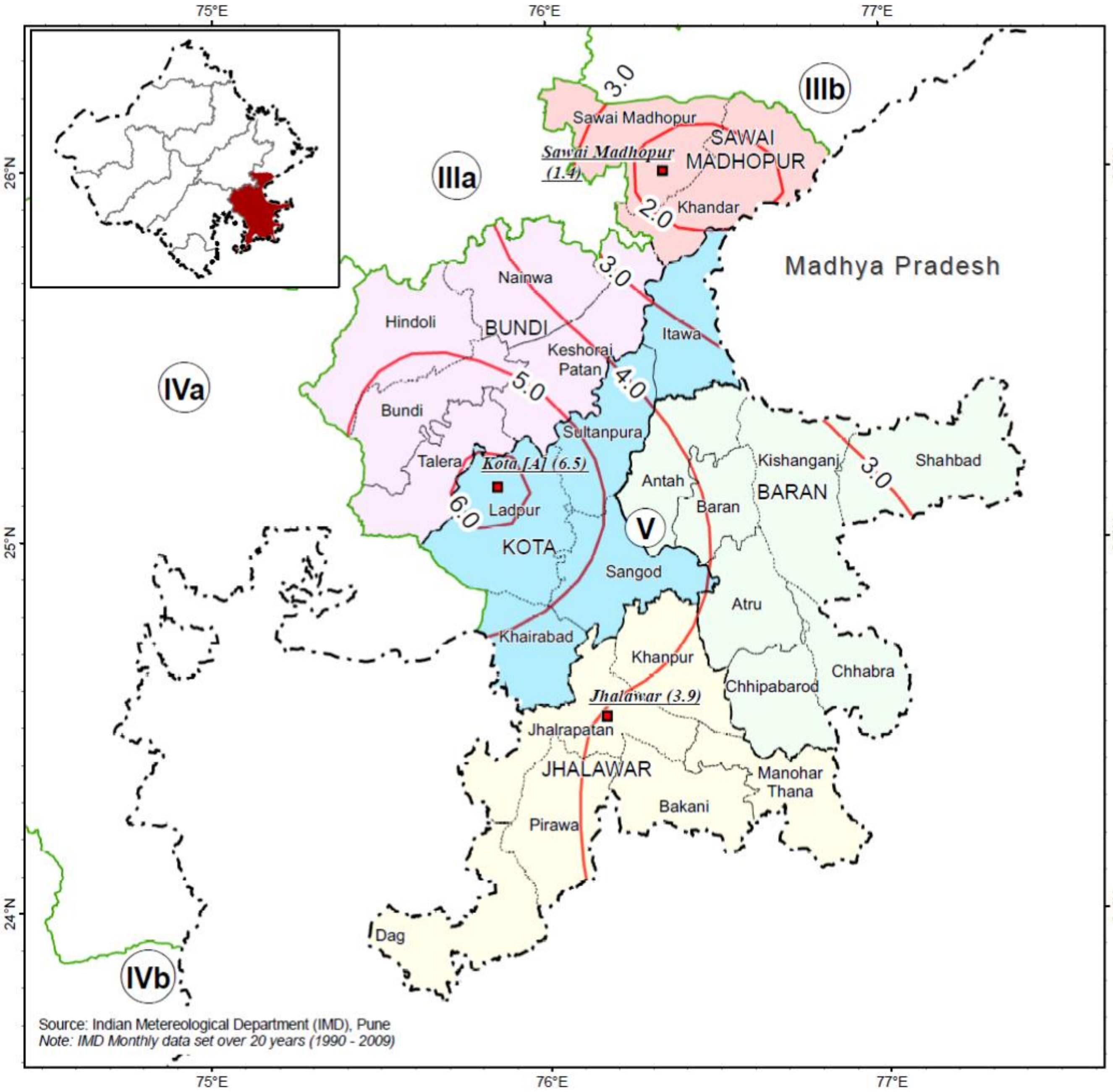
SCALE: 1:1,750,000 | DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)



Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

MEAN ANNUAL DAILY WIND SPEED
Humid South-Eastern Plain (V)
RAJASTHAN

Legend

■ Station Location

Windspeed (km/h)

― Index Isoline (1 km/h)

Boundaries

- Block
- District
- Agroclimatic Zones
- State

Labels

Station Name (Mean Value) — Block

Index Isoline — DISTRICT

ACZ — State

0 20 40 60 80 Km

GOVERNMENT OF RAJASTHAN
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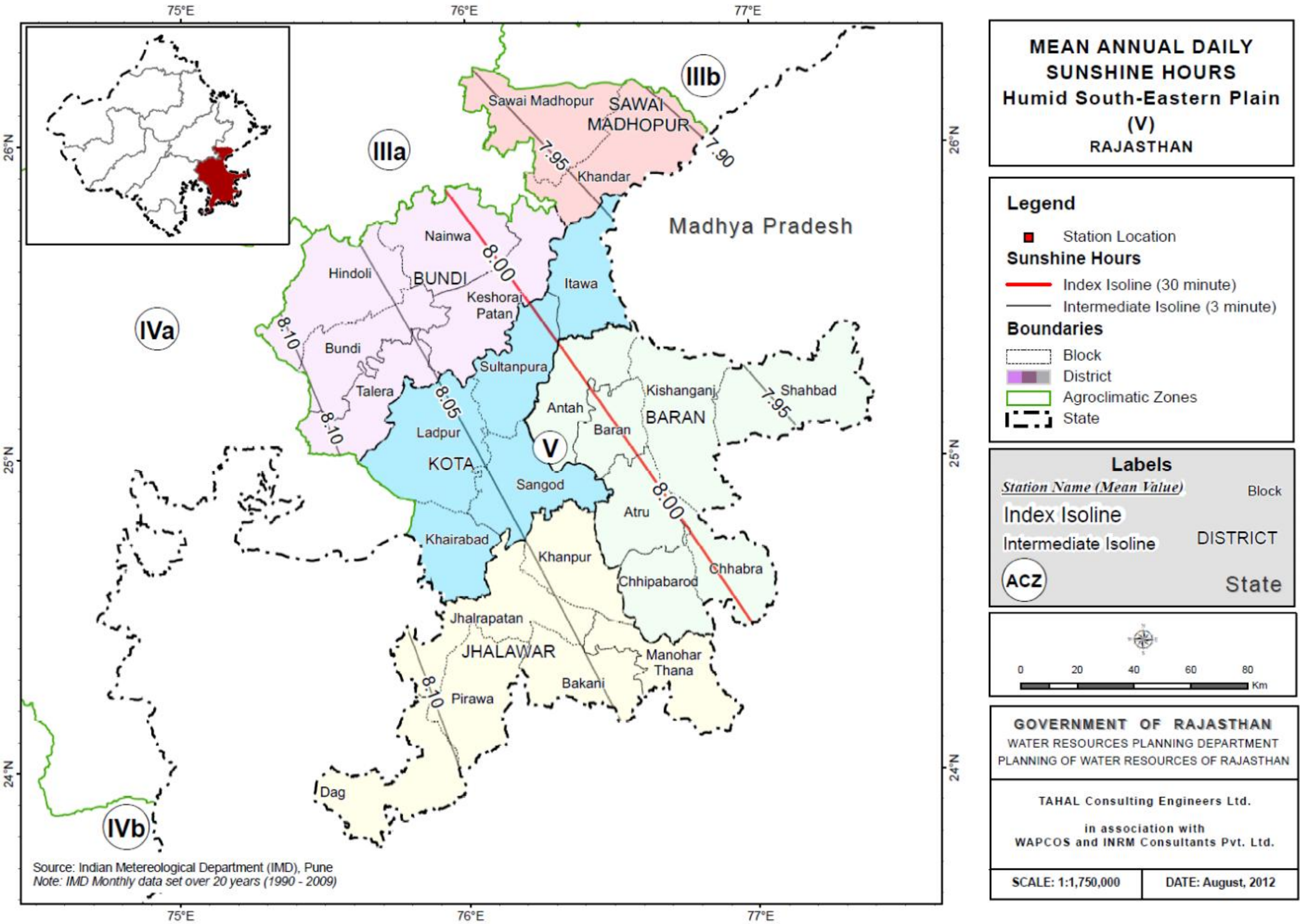
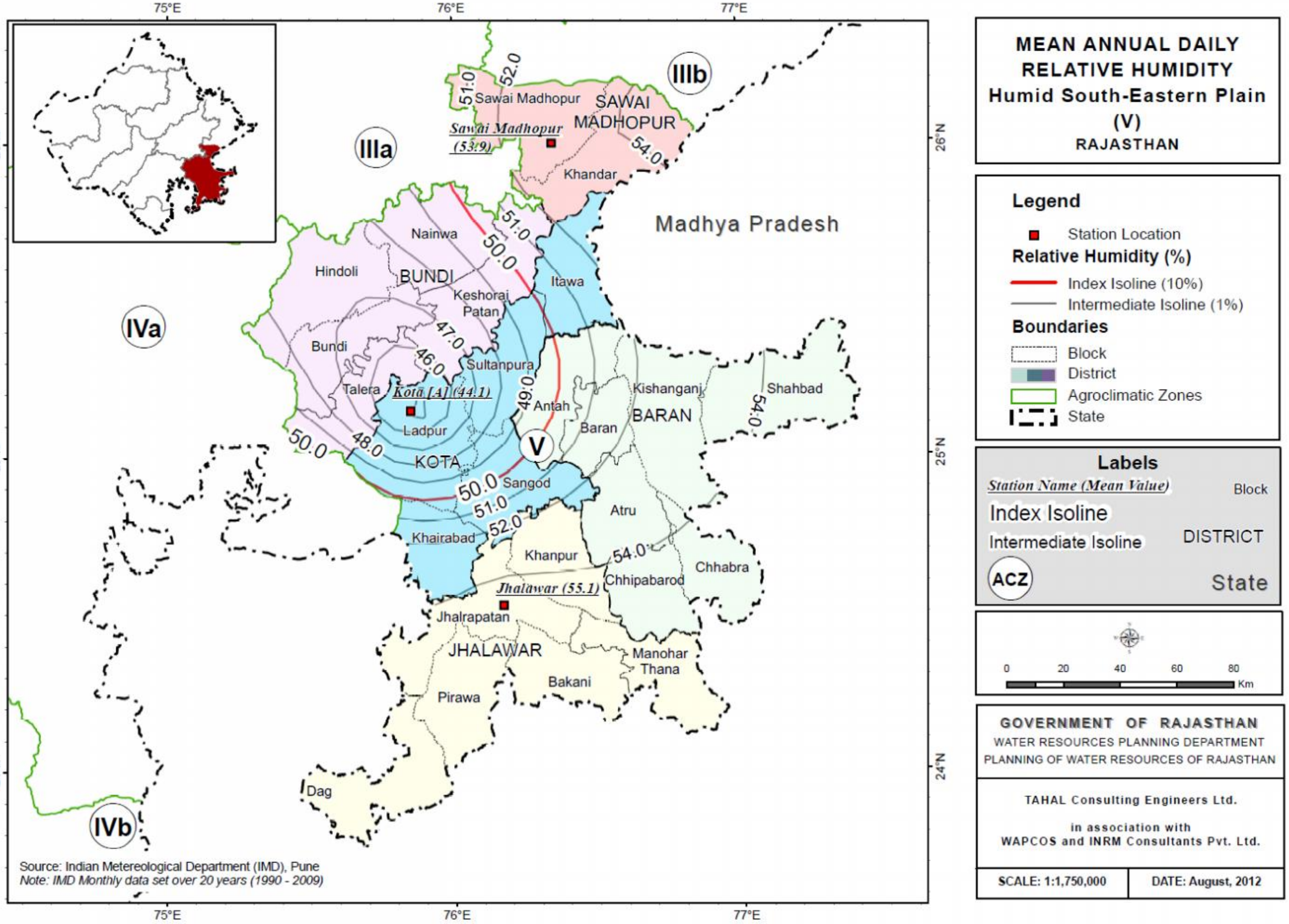
SCALE: 1:1,750,000	DATE: August, 2012



Source: Indian Metereological Department (IMD), Pune

Note: IMD Monthly data set over 20 years (1990 - 2009)



MEAN ANNUAL DAILY RELATIVE HUMIDITY
Humid South-Eastern Plain (V)
RAJASTHAN

Source: Indian Metereological Department (IMD), Pune
Note: IMD Monthly data set over 20 years (1990 - 2009)

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SCALE: 1:1,750,000
DATE: August, 2012